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DEBRIS CLEARING TIMES AFFECTING CRITICAL SURVIVAL ACTIONS

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Jacobs Associates

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Final Report
August, 1973

DCPA Work Unit 3325G
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DEBRIS CLEARING TIMES

AFFECTING CRITICAL SURVIVAL ACTIONS

Final Report

for

THE DEFENSE CIVIL PREPAREDNESS AGENCY
OFFICE OF THE SECRETARY OF THE ARMY
WASHINGTON, D.C. 20301

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13. ABSTRACT

Clearing of emergency rescue routes through street debris would be most urgent operation following a nuclear attack or other massive debris causing event. Paths at least wide enough to pass ambulances, rescue vehicles and fire trucks will be required where there may be survivors or facilities which must be protected for survivors.

This study analyzes the debris potential in 24 residential situations ranging from single family units to multi-story apartments, all subject to 2, 4, 6 and 10 psi overpressures. The effectiveness of the application of the resources which would more than likely be available in the first three hours is evaluated.

At 4 psi, and less, routes can be cleared for rescue in just about any part of a city. Quite a few routes can be cleared at 6 psi except in very densely built up areas and at 10 psi or more routes in three hours will be possible only in areas with very low building density.

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CONSTRUCTION RESOURCE INVENTORY						
EMERGENCY ROADS - CITIES						
RESCUE CITY						
DISASTER RELIEF DEBRIS REMOVAL						

DETACHABLE SUMMARY

DEBRIS CLEARING TIMES AFFECTING CRITICAL SURVIVAL ACTIONS

GENERAL

The most critical time following a nuclear attack or other massive debris creating disaster in a large city would be the first few hours after the event. This study analyzes what might be expected to be achieved in debris clearing in three hours with resources likely to be available to most urban areas after a nuclear explosion. Some 24 different sets of conditions in residential areas are examined with conclusions and recommendations presented.

In an emergency where debris has been deposited in the street, it will be essential to clear many rescue routes through the streets in a very few hours. These routes need be only wide enough for one way passage of rescue cars, ambulances or firetrucks as their primary purpose would be for rescue, fire fighting or fire prevention. The cleared paths may also serve as fire breaks.

The minimum clearing width or path for most equipment is in the range of 10 to 16 feet which is adequate for one way traffic. The equipment operator can take advantage of low spots and avoid higher piles of debris. This would result in a meandering route. Occasionally wide spots should occur naturally and provide sufficient places for vehicle passage. If not, passing areas should be provided.

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PRE-EVENT PLANNING

Cities should be divided into zones for emergency control for all activities, including debris removal. From the standpoint of debris removal, it would be desirable for these zones to be about 5 miles by 5 miles in size and have a marshalling and control area near their center. Shopping centers or school yards, having ample parking space for equipment, are good candidates. These areas are called Multi-purpose Staging Areas or MSA.

From the standpoint of planning debris removal and implementation, it would be desirable to establish zones which would have fairly uniform conditions throughout, such as type of building construction, size, use and density. These ideal conditions will occur infrequently so the established guidelines should be used for the predominant or average physical features within the zone.

A survey of the probable debris conditions has been made for the 24 hypothetical situations in this study; at 2, 4, 6 and 10 psi overpressure for 6 areas of single and multiple unit dwellings, including wood frame buildings, masonry buildings and multi-story apartment houses.

Plans should account for resources required in debris removal i.e., equipment, operators, supplies, etc. which should be inventoried and assigned to MSA's.

DEBRIS SITUATION

The 24 situations examined in detail showed average debris depths

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varying from 0 to 16 feet. There were 16 of less than one foot, 5 from one to three feet and 3 of over three feet deep. Debris volumes varied up to 20 cubic yards per lineal foot of route.

RESOURCES

An analysis of several urban areas makes it fairly certain that there will be enough critical resources i.e. bulldozers and front end loaders, in most areas capable of clearing a significant number of emergency routes within 3 hours. The estimated number of 150 to 300 horsepower tractors needed will be 10 to 20 per zone. Some urban areas would have 10 to 20 zones per city, giving a total of 100 to 200 tractors required per city depending on analysis of debris conditions that would occur.

Operating personnel will be available and can be obtained from local or neighboring union headquarters or general contractors in the area.

PERFORMANCE

Equipment allocation was based on an inventory of equipment in the San Francisco area. For this analysis equipment was mobilized at the MSA in advance of a nuclear event and fueled so that it could operate for at least one eight hour shift without service.

A 5 x 5 mile zone was mapped with an MSA near its center. Sixteen routes of 2-1/2 to 3-1/2 miles in length were plotted for each of 6 zone situations. This route layout would make any spot in the zone within a half mile of a cleared route. In a real situation the plotted routes would go to the most critical spots in the particular zone.

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The analysis showed that:

1. At 2 psi all routes could be cleared in single family and high rise residential areas.
2. At 4 psi nearly all routes could be cleared in single family areas and about 5 in high rise areas.
3. At 6 psi 4 to 16 routes could be cleared in single family areas but none in the high rise areas.
4. At 10 psi one route in each of two of the four single family zone situations could be cleared and about 300 to 9000 lineal feet could be opened in the other 4 zone types.

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PREFACE

This is an analysis of the capability to clear debris rapidly from critical routes of minimum width in an urban area following a nuclear explosion. The objective is to determine how many routes may be cleared through areas of single and multiple unit residential dwellings, within the first three hours after an event. These routes will be cleared for one-lane access of emergency vehicles using standard excavation equipment likely to be available to most cities.

This study has been made by Jacobs Associates under the sponsorship of the Defense Civil Preparedness Agency. Mrs. Eula Stull is Contracting Officer and Mr. M. A. Pachuta is the Contracting Officer's Technical Representative. Mr. Pachuta and Mr. W. E. Strope of the DCPA office have furnished very valuable technical guidance for this analysis.

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ABSTRACT

Equipment most useful in debris clearing for emergency routes through city streets after a nuclear explosion would be bulldozers and front end loaders. In areas where debris quantities are minimal, motor-graders or possibly street sweepers could be used.

Most of these vehicles will clear 10 to 16 foot width in one pass which is more than adequate for one way traffic of ambulances, fire trucks and other rescue vehicles. The naturally occurring, occasional, sparse debris depositions in most cases will provide adequate wide spots for passing oncoming or slower traffic.

Fortunately in most urban areas the above types of equipment are rather plentiful as they are used for general building construction or in street and highway work. Preliminary evaluations indicate that in and near the cities there will be more than one piece of equipment for every two square miles.

This analysis shows that for detonations creating overpressures of 4 psi or less the available equipment and personnel will be able to clear emergency routes to just about any spot within the residential sections of a city within three hours after being deployed. Where pressure is 6 psi routes can be cleared through residential single family areas but only a limited number of routes in high rise construction areas (high building density) can be cleared in that time frame. It will be impossible to clear any significant number of routes at pressures above 6 psi except in areas of very low building density.

General guidelines for debris removal are summarized in Appendix A. These guidelines describe overall procedures for analyzing potential debris situations; locating and mobilizing resources; and assigning resources to specific tasks.

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1.0 INTRODUCTION

Debris removal from the streets for access of emergency vehicles is one of the first activities required in a recovery operation following one of several possible catastrophic events. Such an event might be a nuclear explosion, other enemy activity, an earthquake, one of several kinds of storms, or it may be the result of civil disorders. Several studies have been made as to the effects of a nuclear explosion, which is potentially the most severe of these. The data from prior studies on nuclear explosions are used as a background in this analysis, but the findings may be applicable to any of the other debris forming events.

The principal object of this analysis is to determine the effectiveness of construction equipment which is likely to be available in an urban area in clearing emergency paths during the first few hours following a catastrophic event. As a part of this study effort, guidelines are described to evaluate and implement a debris removal operation using hypothetical situations.

The widths of routes cleared for emergency vehicles need to be about 8 feet. Minimum widths which are possible to clear with available equipment would be at least 8 feet, with some of the equipment paths up to 12 or 16 feet.

The debris planning is separated into three parts. First, available resources such as equipment and operators are located, inventoried and assigned to a particular area based on an overall plan. Next, debris creating potential is assessed for each area taking into account the many variables of physical dimensions and possible severity of damage caused by an explosion. Third, the available resources are assigned specific tasks to evaluate how effective they will be in a variety of situations.

Appendix A of the study gives summarized guidelines for use in appraising a local situation.

2.0 BACKGROUND

Previous studies (Reference 2, etc.) provide data for estimating the volume, nature and distribution of debris using building heights, their concentrations, and the influence of variables such as street width. Debris volume generated is related to the overpressure caused by the explosion in the area to be cleared and whether or not fires have been started or controlled.

Some 20 building types have been described in other studies (Reference 1). Building use has been classified in three categories as commercial, residential and industrial. Only single and multiple unit residential dwellings are considered in this analysis. However, the analysis can be applied to other building type and use categories.

Much of the past work on debris has been with moderately large or large cities as the focal point. This study makes use of data provided by more general work in debris removal for the Detroit and San Francisco areas.

Former debris removal studies have been made with the idea of having a few days to a few weeks in which to perform the total emergency debris removal tasks. This effort is aimed at determining how much can be accomplished in the first critical three hours after an event.

Research studies have been made covering a variety of emergency activities following a nuclear event. These plans include provisions for re-establishing production and distribution of food and utilities and re-establishing facilities for sanitation among other things. These provisional plans also include the administration of the total rescue operation. An accepted supposition of most of these plans is that the urban areas will be divided into zones for administrative control. Ea... zone will have an operating control center where resources will be gathered and these are called Multi-purpose Staging Areas, or MSA.

Analyses have been made regarding the productivity of conventional construction equipment in emergency debris removal operations in Reference 2. These studies have provided data used in this study on resources which might be available.

3.0 HYPOTHETICAL SITUATIONS DEFINED

Several hypothetical situations are described in which building debris would be created by a catastrophic event in a city. The event considered for this study is a nuclear explosion resulting in various ranges of overpressures depending on the distance of a particular area from the point of detonation. Conditions for immediate post event activities and requirements are assumed and described. The basic assumption is that there will be a need for up to sixteen, debris cleared routes per zone, of a minimum width to pass emergency vehicles such as ambulances and fire trucks. A maximum expected route length for each specific task is assumed to be 2.5 to 3.5 miles from any particular MSA.

The situations set up for analysis include several types of residential buildings, including woodframe, multi-story reinforced concrete etc., with one building construction type assumed in each of six hypothetical zones described.

Four levels of damage creating forces, or overpressure, (2, 4, 6 and 10 psi) are analyzed for each of the six zones. Thus the study reflects the analysis of four overpressures for six general types of building construction, or 24 separate situations in all.

An inventory of debris removal resources or construction equipment is assumed. This hypothetical inventory is based on actual inventory data gathered in prior research studies on debris generation and removal in San Francisco. Most of the other assumed parameters are based on similar studies.

The effects of fallout and radioactivity at early times are beyond the scope of this study, therefore, for this analysis it does not matter whether it was a ground or air detonation.

3.1 Route Requirements

The route length depends on the purpose or need for clearing to reach the specific goals. The volume to be handled varies with debris depth. Speed of removal depends on the equipment available. Other considerations may be important in route design, but the purpose, time available and probable route length and depth are the most critical items on which management must base their decisions of priority. Variables such as depth or type of debris are controlled by the event and type of construction within the area and determine the difficulty of clearing the route within a specified time.

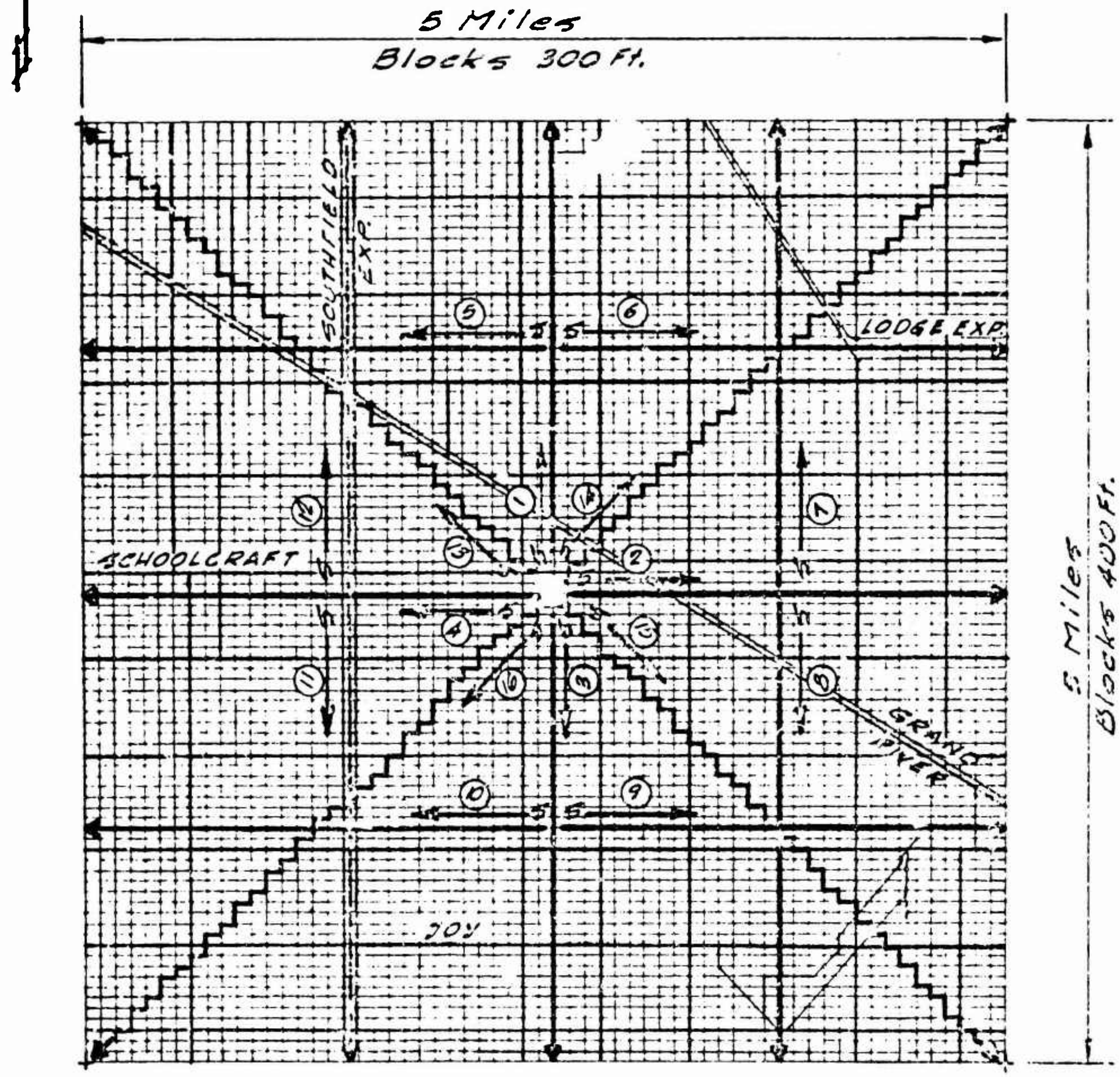
Procedures are analyzed to determine whether resources which are normally expected to be available can clear a route within a reasonable time. An exercise for determining the reliability of a procedure, such as this, should be tested under various circumstances possible in a large city. Detroit has been used as an example in other studies and will be used as a point of reference in this study, but, the analysis will be presented so that the findings may be applied to any other large city.

It is assumed that the city will have been divided into areas or zones for emergency control of civil defense activities and that these zones will average five miles by five miles in size or 25 square miles in area with a centrally located MSA. Major routes will emanate from the MSA but several may start at points other than the MSA, usually by equipment that can crawl over debris between the MSA and other starting points.

The goal of this exercise will be to get a minimum width of access route cleared from the MSA to the outer limits of the zone, in a very few hours. As many of these connecting links as possible will be attempted. By the above definitions of zone, length of routes will vary from about 2.5 miles long to over 3.5 miles. Figure 3.1 shows an idealized zone which will be used as an example.

Sixteen hypothetical tasks or routes have been defined using these assumptions as a guide. (Figure 3.1) Four that are 2.5 mile routes, (and have been rounded off at 13,000 feet long), will start at the central MSA and drive directly to the mid point of each of the 4 sides of the zone. These are numbered 1 through 4. At mid length of each of these four 2.5 mile routes, two additional 2.5 mile long routes will start in opposite directions and, at right angles to the original route. Thus 8 more tasks and route numbers 5 through 12 are added. These latter eight routes originate at some distance from the MSA and so in many cases will be done with crawler equipment which can travel over debris to avoid waiting for the access route to be cleared to the starting point. Resources permitting, four additional routes will be started at the MSA and driven in as direct a line as possible to the four corners of the zone. Each of these diagonal routes will be over 3.5 miles or an assumed 20,000 feet long. These are convenient route assumptions for this analysis to correlate results for varying conditions. Naturally the local situation will dictate actual route locations and direction.

HYPOTHETICAL CITY
RESCUE ZONE



NOTES:

1 - ✱ - M5A

2 - Short arrows with "5" gives start and direction of route.

3 - Numbers in circles with short arrows are route numbers.

4 - Heavy lines are general location of routes.

5 - Arrows on route show end of route.

FIGURE 3.1

The hypothetical routes on Figure 3.1 have a priority based on the smallest route number having the highest priority. It may be necessary to assign equipment to routes of lessor priority if the only equipment remaining to be assigned is rubber tired and the higher priority routes remaining start at some distance from the MSA.

A minimum width of only 8 feet is required for ambulance, truck or rescue automobile, but, at least 10 to 16 feet must be provided in most cases to accommodate the debris removing vehicle's minimum blade or working width. This minimum width will vary from about 10 feet to 12 feet for front end loaders and 12 to 16 feet for bulldozers.

The equipment shown on Table 3.1 is representative of the type of equipment, likely to be available, which can be used effectively in the critical emergency period being considered. It consists of motor graders and different sizes of front end loaders and bulldozers of both wheeled and crawler types. The equipment "code" is part of a system established in Reference 3 and further described in Reference 2. Code numbers have been assigned to all types of excavation equipment to simplify inventory of resources so that, for example, crawler tractors of similar size and capabilities can be grouped together regardless of manufacturer.

3.2 Clearance Time

It is required to establish the clearance capability of equipment in the emergency period in the critical time period immediately following a debris causing event. For this analysis the time available has been established as three hours. It is also assumed that this is an event for which

ROUTE WIDTHS

FOR

EQUIPMENT TYPES SELECTED

EQUIP. CODE	EQUIPMENT DESCRIPTION	Approx. hp.	Norm. Blade Length Feet	Route Width Feet
141	Motor Grader	128	12	14
160	Cr. Fr. End Loader	112	7	10
161	Wh. Fr. End Loader	123	8	10
162	Cr. Fr. End Loader	164	8	10
163	Wh. Fr. End Loader	181	9	10
165	Wh. Fr. End Loader	230	10	12
167	Wh. Fr. End Loader	275	10	12
280	Cr. - Bulldozer	124	11	12
284	Cr. - Bulldozer	225	13	14
286	Cr. - Bulldozer	270	14	16
288	Cr. - Bulldozer	350	15	16

Cr. - Crawler
Wh. - Wheeled

TABLE 3.1

there has been some warning permitting mobilization of equipment fueled for at least one 8 hour shift of operation, and other resources, including man power, at the MSA.

3.3 Purpose

This effort is primarily for rescue of people, passage of fire fighting equipment, or access to essential utilities or other resources. Fires, which may have been set by the event, or its after-effects, are in the ignition stage and will not affect the volume or type of the debris, nor will its presence be severe enough to affect the efficiency of the debris removal operation.

3.4 Building Type and Use

It is unlikely that many cities will have any area 5 miles square which will be completely composed of buildings for one use, or of one type of construction. For the purpose of evaluation of techniques, however, the assumption is made that there are six distinct homogeneous areas of this 5 x 5 mile size and that only one type and use of building does predominate in each of them. This predominance of structure types is a possible occurrence in some cities.

The northwest section of Detroit is about 5 x 10 miles of area fairly uniformly saturated with single family dwellings. Most of these are masonry construction. The western part of the south central section of the city contains an area that is almost 5 x 5 miles of saturated industrial construction. All other areas are a heterogeneous mixture of two family or multi-family units with commercial industrial buildings interspersed.

This general description would fit several other cities. There are some that are less saturated, or congested, such as Los Angeles and Houston. Some are more concentrated such as New York and San Francisco. All probably have one area which would present a problem potential similar to one of those used in this study.

As has been stated, it is assumed that there are six distinct residential areas each having one type of construction predominating as shown in Table 3.2. This table also shows the assumed street width, the percentage of land covered by buildings and other pertinent data that would have been observed on pre-event surveys and recorded on Debris Prediction Survey forms (DPS forms from Reference 2) for that purpose for each zone. These DPS forms will be described in Section 5 of this study. All blocks are presumed to be 300 feet x 400 feet.

An analysis of Table 3.2 will show that the first three zones could be classed as zones of single family dwellings on normal city lots with space around them. The first two are frame and the third is brick. Zone four would represent a town house type of construction where single family units join each other and are very close to, or are adjacent to, the street line. Zones five and six are multi-story apartment complexes, representing two heights and differences in construction.

3.5 Other Inclusions

It will be assumed that there are a moderate number of trees and poles in each of the areas and that traffic was negligible because of the pre-warning period.

PHYSICAL DESCRIPTION

OF

SIX ZONES

ZONE NO.	BUILDING USE	AVERAGE BUILDING HGT. FT.	% LAND COVERED BY BUILDINGS	STREET WIDTH FEET	BLDG. TYPE *
1	Resid.	30	20	80	1
2	Resid.	50	20	80	1
3	Resid.	50	20	80	2
4	Resid.	50	50	60	2
5	Resid.	100	70	60	14
6	Resid.	200	70	60	11

* Building type is from Reference 1 and for those used here are:

1 - Wood Frame

2 - Unreinforced Masonry

11 - Multi-Story Steel Reinforced Concrete Frame Shearwall

14 - Multi-Story Steel Frame Masonry Exterior Panels

TABLE 3.2

4.0 DEBRIS CLEARING EQUIPMENT

Only certain types of excavation equipment will be useful for debris removal during the first three hours after a disaster. Fortunately these types are usually found in all cities. Methods of judging their performance are given.

4.1 Equipment Allocation

A construction equipment inventory was made for the San Francisco metropolitan area in Reference 2. In this report the assumption is made that similar equipment quantities and types would be available in any large metropolitan area of the same approximate size, including Detroit, the focal point of this study. This seems to be a valid conclusion by the investigators who have been active in the use and or sale or purchase of this type of equipment in nearly every area of the United States. This might be checked in the future to see if there is a significant difference in equipment availability in the various areas of the nation with respect to number of units per square mile, type of equipment or size of units.

A summary of the type of key equipment in the San Francisco inventory which is appropriate to be used for this exercise is shown in Table 4.1. It is assumed that only bulldozers, front end loaders and motor graders will be used in the immediate post event situation. Power shovels will not be considered as they are too slow to clear any significant distance in three hours; and if debris is deep enough to require power shovels there won't be many routes cleared in three hours. Table 4.1 shows a reasonable equipment allocation to each of 16 zones, assuming the city or area had six-

EQUIPMENT CITY INVENTORY

AND ALLOCATION TO ZONES

(ASSUMED QUANTITIES)

Equip. Code	City Total	No. To Zone	Approx. H.P.	Brief Description CR = Crawler WH - Wheeled
141	39	2	125	Motor Grader
145	2	0	225	Motor Grader
160	19	1	120	CR- F.E.L. *
161	17	1	125	WH- F.E.L.
162	26	3	160	CR- F.E.L.
163	23	2	180	WH- F.E.L.
165	20	1	230	WH - F.E.L.
166	1	0	254	CR- F.E.L.
167	9	1	300	WH- F.E.L.
169	5	0	300	WH- F.E.L.
176	1	0	275	CR-F.E.L. Side Dump
264	8	0	210	2 Cu.Yd.Shovel-CR
280	31	2	125	CR - Dozer
283	1	0	170	WH - Dozer
284	12	2	225	CR- Dozer
286	37	2	275	CR - Dozer
288	13	1	350	CR- Dozer
289	4	0	300	WH- Dozer

* F.E.L. is Front End Loader; CR is Crawler; WH is Wheeled

TABLE 4.1

teen zones to supply.

The allocation of equipment is based on the assumption that the metropolitan area of Detroit and similar cities will be about 20 miles by 20 miles in dimension, or that equivalent in area. This means that there will be an average of about 16, 5 mile x 5 mile zones in such a metropolitan complex. Perhaps these 16 zones will include several smaller cities as well as the major city. The allocations of equipment quantities by types shown in Table 4.1 are based on the assumption of the viability of the San Francisco equipment inventory's being approximately duplicated in other similar urban areas. The allocated equipment will be used in Section 6 in planning debris removal capability.

The equipment coding mentioned earlier deserves a short description here. It is described in detail in Reference 2. Each type and size of construction equipment was given a code number to simplify inventory and control. For example a Code 284 is any crawler bulldozer from 201 to 250 HP. It could be a Caterpillar D7, an International Harvester TD20, an Allis Chalmers HD 16 or a Terex 82-30. The first two numbers represent the type of equipment and the third number the relative size.

It is assumed that the 16 dozers and/or front end loaders and 2 motorgraders have been assembled at the MSA prior to the nuclear event. While the motorgraders cannot traverse any appreciable depth of debris laden streets, they will be useful in maintaining previously cleared routes. In light damage areas they are particularly useful for clearing broken glass and small objects that could cause tire damage. Each piece will have been serviced and have enough fuel, for an expected minimum of 8 hours operation. At least one operator and helper for each unit will have been assigned and will be on call at the MSA.

5.0 DEBRIS PREDICTION - FOR ASSUMED SITUATIONS

The type of debris generated will depend on building construction and use. The volume and distribution of the debris in the streets will depend on building volume, building spacing, overpressure and other factors. The principal factors are building type and size, and character of the event which causes debris. Only blast effect, and not fire, is considered as the debris generator in this exercise.

5.1 Debris Prediction Survey

The prior studies such as Reference 2 provide Debris Prediction Survey (DPS) methods and forms to be used in a pre-event analysis. Six of these DPS forms have been filled out with one for each of the zones in this study and are included at the end of this section as Tables 5.6 through 5.11. The data for filling out these six forms can be determined from site and situation descriptions presented in the earlier parts of this report using applicable factors and procedures described in detail in Reference 2. These procedures will be repeated briefly in this section in illustrating their application to the hypothetical situations. All applicable tables of factors are included in Appendix B of this report and suitably referenced in the work tables and text following.

In a real situation most of the information at the top of the DPS forms will have been obtained by actual field survey and observation. Various types of city maps can be used as well as Sanborn commercial maps which show construction methods & building's use, normally for insurance purposes. Block size, street width, building coverage estimates, building type, height and use can be obtained from one or the other of these maps, and checked by a drive through survey. The survey will provide any comments of unusual conditions, and an estimate of increased difficulty of debris removal caused by trees and poles or light standards.

5.2 Potential Debris Volume

The contained volume of buildings is an indicator of the debris which can be generated. Reference 2 explains that this volume is a relative factor based on an averaging of the buildings within the zone. Previous studies have provided an approach to averaging these building volumes. This is expressed as an "Equivalent Building Strip" or EBS which is the width of a continuous average height building surrounding each block which would contribute the same amount of debris as do all of the buildings in that block. Table 5.1 has been prepared to illustrate how the potential debris volume is determined for the DPS sheet.

The EBS (I) for each zone can be found in Table B.1 using block size (A) and the percentage of building coverage (C) data from the DPS. The contained volume (J) is obtained by multiplying the EBS by the average building height (I) x (D). Building height is assumed for this study, but can be determined on a pre-event survey in a real situation.

The resulting building volume quantities must be converted into potential debris volume. The debris volume (L) can be obtained by multiplying the building volume by a previously determined factor from Table B. 2. This gives the volume of material contained in the buildings which would generate debris.

POTENTIAL DEBRIS VOLUME

ZONE	% BUILDING COVERAGE	BUILDING HEIGHT	EBS EQUIVALENT BUILDING STRIP	CONTAINED VOLUME (D) x (I)	BLAST EFFECT FACTOR	POTENTIAL DEBRIS VOLUME (J) x (K)
DPS FORM REFERENCE	(C)	(D)	(I)	(J)	(K)	(L)
FACTOR TABLE REFERENCE NO.	-	-	B.1	-	B.2	-
1	20	30	18	540	.218	117
2	20	50	18	900	.218	196
3	20	50	18	900	.378	340
4	50	50	50	2500	.378	945
5	70	100	77	7700	.330	2541
6	70	200	77	15400	.276	4250

TABLE 5.1

5.3 Off Site Debris

In a problem of clearing emergency passage routes through the streets, such as this, only the off site debris in the street is important, and that debris which settles on the area occupied by buildings can be ignored, temporarily.

The average depth of debris on the streets can be computed by multiplying the off site debris volume by a factor related to street width and block size. It is necessary first to figure the total off site debris volume. This is related to building type and overpressure. Factors for off site debris are shown in Table B.3. The off site debris is the product of the appropriate factor from Table B.3 multiplied by potential volume of debris in each zone from Table 5.1. Work Table 5.2 summarizes this potential off site volume and the factor for each of the four overpressure situations in the six described zones. It gives the off site debris volume in cubic feet per foot of route length. Factors established for overall average depth are given in Table B.4 and resultant depths are summarized in Table 5.2 for the zones described here.

5.4 Emergency Route Debris Volume

The average depth of off site debris as shown in Table 5.2 will be useful in the longer range plans for debris removal from the streets. It is recognized that in this study (for the critical emergency period of the first three hours after an event) only the fastest possible routes to open will be cleared for emergency access. In many cases this will mean a meandering

OFF SITE DEBRIS

ZONE	OVER-PRESSURE	POTENTIAL DEBRIS VOLUME	OFF SITE DEBRIS FACTOR	OFF SITE DEBRIS VOLUME (3) x (L)	STREET WIDTH	AVERAGE DEPTH FACTOR	AVERAGE DEPTH IN STREET (4) x (M)
DPS FORM REFERENCE		(L)	(3)	(4)	(B)	(M)	(5)
FACTOR TABLE REFERENCE NO.		-	B.3	-	-	B.4	-
1	2	117	0	0	80	.008	0
	4		.274	32			0.26
	6		.600	71			0.57
	10		.600	71			0.57
2	2	196	0	0	80	.008	0
	4		.274	54			0.43
	6		.600	118			0.94
	10		.600	118			0.94
3	2	340	0	0	80	.008	0
	4		0	0			0
	6		.050	17			0.14
	10		.600	204			1.63
4	2	945	0	0	60	.011	0
	4		0	0			0
	6		.050	47			0.52
	10		.600	567			6.24
5	2	2541	0	0	60	.011	0
	4		.019	48			0.53
	6		.106	269			2.96
	10		.600	1525			16.77
6	2	4250	0	0	60	.011	0
	4		.008	34			0.37
	6		.028	119			1.31
	10		.112	476			5.24

TABLE 5.2

route rather than one in a straight line.

In clearing a single lane for emergency situations it is logical and more efficient to clear a path of least resistance, i.e. minimum depth. Where possible the operator will avoid high mounds of debris leaving these for a more complete cleanup later. Except in cases of high overpressures resulting in uniform debris distribution (Ratio of maximum to average depth = 1:1), the average depth in this meandering lane will be less than the average for the total street width. A graphic illustration of this situation is given for zone no. 1, single family wood frame buildings, in Figure 5.1. It can be seen that although structural demolition takes place with as little as 4 psi overpressure, higher overpressures result in more leveling of the debris, which has the effect of raising the average depth and volume of the meandering route and reducing the total distance that can be cleared in a given time. The situation is similar in the other zones considered.

Previous studies have predicted such things as probable minimum and maximum depths of debris in different situations. These variations have been used with probability analysis techniques to provide additional factors to adjust the average overall off site debris depth to a lesser average depth for a meandering route. These factors are shown in Table B.5. They are applied to this problem situation in Table 5.3 to achieve an adjusted average route depth.

The volume of debris per 1000 feet of route can now be computed using the formula:

EFFECT OF BLAST ON SINGLE FAMILY WOOD FRAME BUILDINGS (ZONE 1)

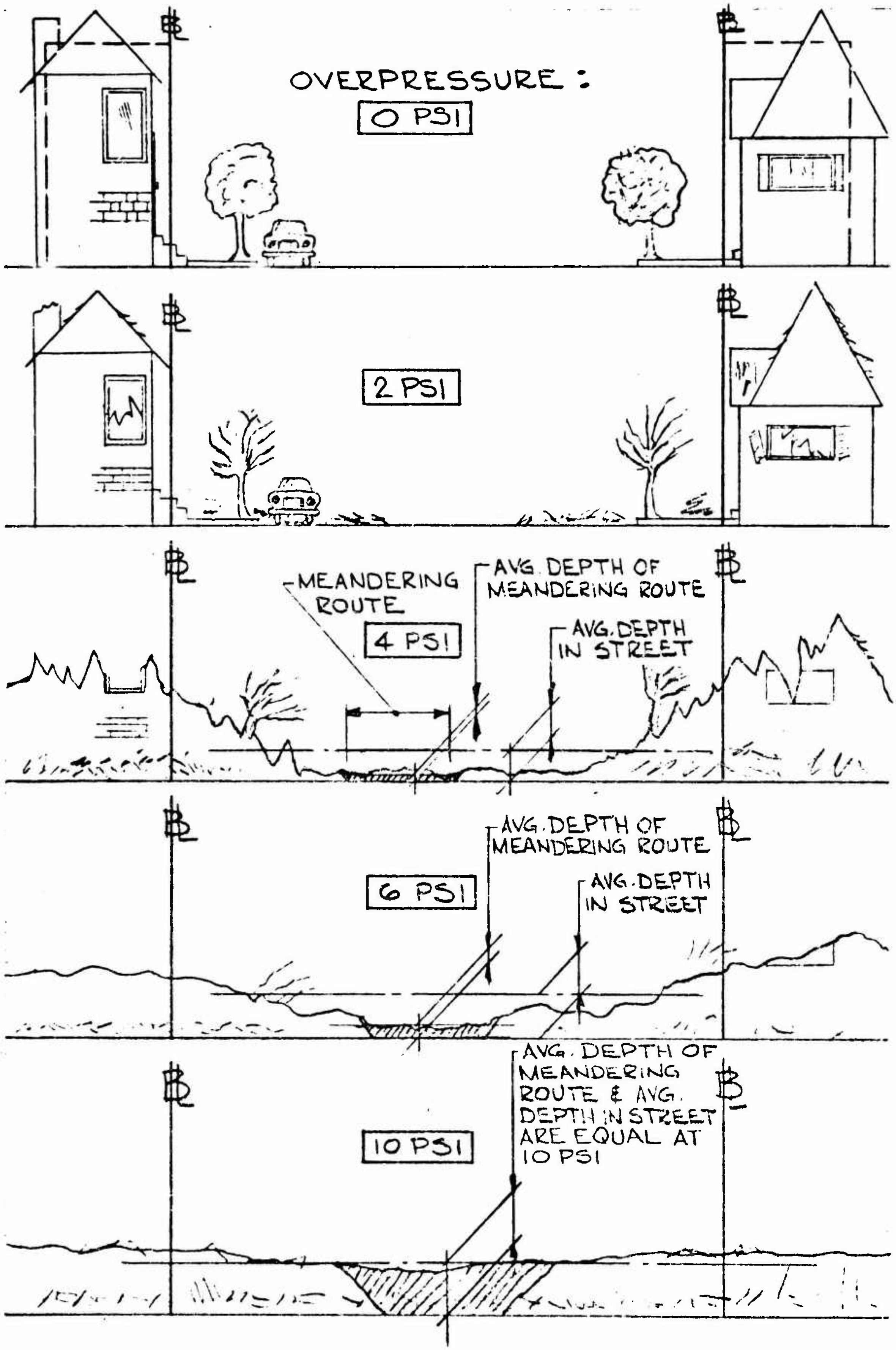


FIGURE 5.1

MEANDERING DEPTHS

ZONE	BLDG. HGT. FT. D	STREET WIDTH FT. B	D/B	ROUTE DEBRIS DEPTH	OVERPRESSURE 2	4	6	10
1	30	80	.375	Average Depth Factor Route Depth	0 0.15 0	0.26 0.20 0.05	0.57 0.30 0.17	0.57 1.00 0.57
2	50	80	.625	Average Depth Factor Route Depth	0 0.15 0	0.43 0.20 0.09	0.94 0.30 0.28	0.94 1.00 0.94
3	50	80	.625	Average Depth Factor Route Depth	0 0.15 0	0 0.20 0	0.14 0.30 0.04	1.63 1.00 1.63
4	50	60	0.833	Average Depth Factor Route Depth	0 0.20 0	0 0.25 0	0.52 0.40 0.21	6.24 1.00 6.24
5	100	60	1.667	Average Depth Factor Route Depth	0 0.20 0	0.53 0.40 0.21	2.96 0.60 1.78	16.77 1.00 16.77
6	200	60	3.333	Average Depth Factor Route Depth	0 0.30 0	0.37 0.60 0.22	1.31 1.00 1.31	5.24 1.00 5.24

TABLE 5.3

$$V = 37\ (d\ W + d^2)$$

Where: V = Volume of debris in cu. yd./1000 ft. route

d = Average depth feet

W = Width of route in feet

The cu. yds. per 1000 feet of route length for the 4 route widths of each of the 24 situations of the defined problem having any appreciable depth, are shown in Table 5.4.

The defined routes are of two lengths. There are 12 routes of 2.5 miles which are rounded off at 13,000 feet each for this study. There are 4 longer routes of slightly over 3.5 miles which are rounded off at 20,000 feet each. These longer ones are situated diagonally in the zone and must meander by blocks as well as seeking ease of way through the more shallow debris. Table 5.5 shows the volume of debris in 1000 cu. yds. per route for the long and short routes in each zone and for each overpressure which will produce significant debris, for each of several route widths. These tables are not required to complete the DPS sheets but incorporate the information thus found. They w[illegible]ed in Section 6 for determining the amount of debris removal possible in each hypothetical situation.

To complete the DPS forms, the ratio of maximum depth to average depth for column (6) of the DPS can be found on Table B.6. The product of this ratio and average depth from column (5) gives the maximum depth for column (7).

Column (2) of the DPS is for a letter rating of "L" (Light), "M" (Medium) or "S" (Severe) to define the overall damage. Generally, anything

DEB?.S PER 1,000 FEET OF ROUTE

CU.YD.

ZONE	OVER-PRESSURE p.s.i.	VOLUME CU.YDS./1,000 FT. ROUTE ROUTE WIDTH - FT.			
		10	12	14	16
1	4	18	22	26	30
	6	64	77	89	103
	10	223	265	307	350
2	4	34	40	47	54
	6	107	127	148	169
	10	380	450	519	589
3	6	15	18	21	24
	10	702	822	943	1063
4	6	79	95	110	125
	10	3750	4200	4650	5150
5	4	79	95	110	125
	6	775	905	1040	1170
	10	16,610	17,851	19,092	20,333
6	4	83	99	115	131
	6	548	645	740	839
	10	2955	3343	3730	4119

Note: 2 psi not shown for any zone and 4 psi not shown for zones 3 or 4 as no significant debris is in streets.

TABLE 5.4

1000 CUBIC YARDS DEBRIS PER ROUTE

ZONE	OVER-PRESSURE p.s.i.	SHORT ROUTE 2.5 MILES ROUTE WIDTH - FEET				LONG ROUTE - 3.5 MILES ROUTE WIDTH - FEET			
		10	12	14	16	10	12	14	16
1	4 6 10	0.23 0.83 2.90	0.29 1.00 3.45	0.34 1.16 3.99	0.39 1.34 4.55	0.36 1.28 4.46	0.44 1.50 5.30	0.52 1.78 6.14	0.60 2.06 7.00
2	4 6 10	0.44 1.39 4.94	0.52 1.65 5.85	0.61 1.92 6.75	0.70 2.20 7.66	0.68 2.14 7.60	0.80 2.54 9.00	0.94 2.96 10.38	1.08 3.38 11.78
3	6 10	0.20 9.13	0.23 10.69	0.27 12.26	0.31 13.82	0.30 14.04	0.36 16.44	0.42 18.86	0.48 21.26
4	6 10	1.03 48.80	1.24 54.60	1.43 60.50	1.63 67.00	1.58 75.00	1.90 84.00	2.20 93.00	2.50 103.00
5	4 6 10	1.03 10.10 215.90	1.24 11.80 232.10	1.43 13.50 248.20	1.62 15.20 264.30	1.58 15.50 332.20	1.90 18.10 357.00	2.20 20.80 381.80	2.50 23.40 406.70
6	4 6 10	1.08 7.1[illegible] 38.40	1.29 8.40 43.50	1.50 9.60 48.50	1.70 10.90 53.50	1.66 11.00 59.10	1.98 12.90 66.90	2.30 1.48 74.60	2.62 16.80 82.40

TABLE 5.5

for overpressures of 4 or less will be light, 4 to 6 will be moderate, and over 6 will be severe.

Table B.7 gives maximum size of debris for column (8).

The building content code for column (9) can be judged using the following guideline for the structural character of the debris:

No Steel or Wood	- Code 1
Light Steel or Wood	- Code 2
Medium to Heavy Wood - No Steel	- Code 3
Medium Steel	- Code 4
Heavy Steel	- Code 5

Similar numbers might be put in column (10) depending on the judgment of the drive through debris surveyors as to the difficulty that may result from those trees and poles in the area. It will be a flag only in evaluating debris type and expected equipment performance.

The debris type in column (11) is a judgment entry of the type of debris anticipated, using factors in Table B.8 as a guide. If the DPS is made when traffic is known, the value entered in column (11) can be adjusted as shown on B.9 for actual traffic conditions of:

1. Light;
2. Medium; or
3. Heavy.

- ZONE NO. 1

(A) Block Size 300 x 400 (B) Street Width 80 (C) Building Coverage 20% (D) Ave. Bldg. Height 30

(E) Building Type 1 (F) Building Use Residential (G) Trees - Poles Light

(H) Comments

(I) E.B.S. 18 (J) Contained Vol. 540 (K) Material Factor: Blast .218 ; Blast and Fire .026

(L) Potential Debris Material: Blast 117 ; Blast and Fire 14 (M) Ave. Depth Factor .008 (N) D ÷ B 0.375

PREDICTED ENVIRONMENTS

ATTACK CONDITION	(1) Incident Over-Pressure PSI	(2) Damage Light-L Moderate-M Severe-S	(3) Off Site Factor	(4) Vol. Off Site Debris Cu.Ft./Lin.Ft	(5) Average Depth Feet	(6) Ratio Maximum To Average Depth	(7) DEBRIS DESCRIPTION: Maximum Depth	(8) DEBRIS DESCRIPTION: Maximum Size	(9) DEBRIS DESCRIPTION: CONTENTS: Building	(10) DEBRIS DESCRIPTION: CONTENTS: Trees Etc.	(11) PREDICTED DEBRIS TYPE
BLAST ONLY	2	M	0	0	0	--	0	--	--	--	None
	4	S	.274	32	.26	6:1	1.56	30	2	1	3-2
	6	S	.600	71	.57	4:1	2.28	30	2	1	3-2
	10	S	.600	71	.57	1:1	0.57	30	2	1	3-2
BLAST AND FIRE											

TABLE 5.6

__________ - ZONE NO. 2

(A) Block Size 300 x 400 (B) Street Width 80 (C) Building Coverage 20% (D) Ave. Bldg. Height 50

(E) Building Type 1 (F) Building Use Residential (G) Trees - Poles Light

(H) Comments

(I) E.B.S. 18 (J) Contained Vol. 900 (K) Material Factor: Blast .218 ; Blast and Fire .026

(L) Potential Debris Material: Blast 196 ; Blast and Fire 23 (M) Ave. Depth Factor .008 (N) D ÷ B 0.625

PREDICTED ENVIRONMENTS

ATTACK CONDITION	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Incident Over-Pressure PSI	Damage Light-L Moderate-M Severe-S	Off Site Factor	Vol. Off Site Debris Cu.Ft./Lin.Ft	Average Depth Feet	Ratio Maximum To Average Depth	DEBRIS DESCRIPTION				PREDICTED DEBRIS TYPE
							Maximum Depth	Maximum Size	CONTENTS		
									Building	Trees Etc.	
BLAST ONLY	2	M	0	0	0	--	0	--	--	--	None
	4	S	.274	54	.43	6:1	2.58	30	2	1	3-2
	6	S	.600	118	.94	4:1	3.76	30	2	1	3-2
	10	S	.600	118	.94	1:1	0.94	30	2	1	3-2
BLAST AND FIRE											

TABLE 5.7

______ - ZONE NO. 3

(A) Block Size 300 x 400 (B) Street Width 80 (C) Building Coverage 20% (D) Ave. Bldg. Height 50

(E) Building Type 2 (F) Building Use Residential (G) Trees - Poles Light

(H) Comments

(I) E.B.S. 18 (J) Contained Vol. 900 (K) Material Factor: Blast .378 ; Blast and Fire .186

(L) Potential Debris Material: Blast 340 ; Blast and Fire 167 (M) Ave. Depth Factor .008 (N) D ÷ B .625

PREDICTED ENVIRONMENTS

ATTACK CONDITION	(1) Incident Over-Pressure PSI	(2) Damage Light-L Moderate-M Severe-S	(3) Off Site Factor	(4) Vol. Off Site Debris Cu.Ft./Lin.Ft	(5) Average Depth Feet	(6) Ratio Maximum To Average Depth	(7) DEBRIS DESCRIPTION: Maximum Depth	(8) DEBRIS DESCRIPTION: Maximum Size	(9) DEBRIS DESCRIPTION: CONTENTS: Building	(10) DEBRIS DESCRIPTION: CONTENTS: Trees Etc.	(11) PREDICTED DEBRIS TYPE
BLAST ONLY	2	L	0	0	0	--	0	--	--	--	None
	4	M	0	0	0	--	0	--	--	--	None
	6	M	.05	17	.14	4:1	0.56	30	1	1	3-2
	10	S	0.6	204	1.63	1:1	1.63	30	1	1	3-2
BLAST AND FIRE											

TABLE 5.8

________ - ZONE NO. 4

(A) Block Size 300 x 400 (B) Street Width 60 (C) Building Coverage 50% (D) Ave. Bldg. Height 50

(E) Building Type 2 (F) Building Use Residential (G) Trees - Poles Light

(H) Comments ________

(I) F.B.S. 50 (J) Contained Vol. 2500 (K) Material Factor: Blast .378 ; Blast and Fire .186

(L) Potential Debris Material: Blast 945 ; Blast and Fire 465 (M) Ave. Depth Factor .011 (N) D ÷ B 0.833

PREDICTED ENVIRONMENTS

ATTACK CONDITION	(1) Incident Over-Pressure PSI	(2) Damage Light-L Moderate-M Severe-S	(3) Off Site Factor	(4) Vol. Off Site Debris Cu.Ft./Lin.Ft	(5) Average Depth Feet	(6) Ratio Maximum To Average Depth	(7) DEBRIS DESCRIPTION: Maximum Depth	(8) DEBRIS DESCRIPTION: Maximum Size	(9) DEBRIS DESCRIPTION: CONTENTS: Building	(10) DEBRIS DESCRIPTION: CONTENTS: Trees Etc.	(11) PREDICTED DEBRIS TYPE
BLAST ONLY	2	L	0	0	0	--	0	--	--	--	None
	4	M	0	0	0	--	0	--	--	--	None
	6	M	.05	47	.52	3:1	1.56	30	1	1	3-2
	10	S	.60	567	6.24	1:1	6.24	30	1	1	3-2
BLAST AND FIRE											

TABLE 5.9

________ - ZONE NO. 5

(A) Block Size 300 x 400 (B) Street Width 60 (C) Building Coverage 70% (D) Ave. Bldg. Height 100

(E) Building Type 14 (F) Building Use Residential (G) Trees - Poles Light

(H) Comments

(I) E.B.S. 77 (J) Contained Vol. 7700 (K) Material Factor: Blast 0.330 ; Blast and Fire 0.190

(L) Potential Debris Material: Blast 2541 ; Blast and Fire 1463 (M) Ave. Depth Factor .011 (N) D ÷ B 1.667

PREDICTED ENVIRONMENTS

ATTACK CONDITION	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Incident Over-Pressure PSI	Damage Light-L Moderate-M Severe-S	Off Site Factor	Vol. Off Site Debris Cu.Ft./Lin.Ft	Average Depth Feet	Ratio Maximum To Average Depth	DEBRIS DESCRIPTION				PREDICTED DEBRIS TYPE
							Maximum Depth	Maximum Size	CONTENTS		
									Building	Trees Etc.	
BLAST ONLY	2	L	0	0	0	--	0	--	--	--	None
	4	L	.019	48	.53	3:1	1.59	14	3	1	2-3
	4	M	.106	269	2.96	2:1	5.92	30	3	1	3-3
	10	S	.600	1525	16.77	1:1	16.77	48	5	1	4-3
BLAST AND FIRE											

TABLE 5.10

________ - ZONE NO. 6

(A) Block Size 300 x 400 (B) Street Width 60 (C) Building Coverage 70% (D) Ave. Bldg. Height 200

(E) Building Type 11 (F) Building Use Residential (G) Trees - Poles Light

(H) Comments

(I) E.B.S. 77 (J) Contained Vol. 15,400 (K) Material Factor: Blast .276 ; Blast and Fire .132

(L) Potential Debris Material: Blast 4250 ; Blast and Fire 2033 (M) Ave. Depth Factor 0.011 (N) D ÷ B 3.33

PREDICTED ENVIRONMENTS

ATTACK CONDITION	(1) Incident Over-Pressure PSI	(2) Damage Light-L Moderate-M Severe-S	(3) Off Site Factor	(4) Vol. Off Site Debris Cu.Ft./Lin.Ft.	(5) Average Depth Feet	(6) Ratio Maximum To Average Depth	(7) DEBRIS DESCRIPTION: Maximum Depth	(8) DEBRIS DESCRIPTION: Maximum Size	(9) DEBRIS DESCRIPTION: CONTENTS: Building	(10) DEBRIS DESCRIPTION: CONTENTS: Trees Etc.	(11) PREDICTED DEBRIS TYPE
BLAST ONLY	2	L	0	0	0	--	0	--	--	--	None
	4	L	.008	34	0.37	2:1	.74	30	3	1	3-3
	6	M	.028	119	1.31	1:1	1.31	48	4	1	4-3
	10	M	.112	476	5.24	1:1	5.24	48	4	1	[illegible]-3
BLAST AND FIRE											

TABLE 5.11

6.0 DEBRIS CLEARING TIMES

The time required to clear paths through debris depends on the volume and type of debris and the capacity of the equipment. The amount of debris for the hypothetical routes have been established in Section 5. The appropriate equipment types and capacities have been reviewed in Section 4.

In this section assumptions are made pertaining to limitations in productivity with respect to debris removal, using guidelines established in Reference 2. Equipment production rates are analyzed in six assumed zones for each of four different overpressures. Results of these analyses are shown on Task Evaluation Sheets. A summary is made of the total route clearing that can be expected within three hours in all of the assumed 24 debris situations.

6.1 Debris Inclusion

Certain features of the debris, which will affect its removal, or ease of clearance from routes, are expressed in the debris type code given in column (11), the right hand column of the DPS sheets. A familiarity with debris types will make it possible to relate this code to approximate maximum size and depth of debris. Production rates have been set up for debris removal and related to debris type classification.

All of the debris conditions can be predetermined by data compiled for the DPS sheet except the variable for traffic. This condition is not known until the event occurs. Adjustment to the building debris types due to traffic conditions, can be found in Reference Table B.9. Light traffic situations have been assumed for the six zones in this study, and adjustments to debris types made accordingly.

6.2 Equipment Productivity

The equipment which has been allocated to each of the zones is shown on Tables 3.1 and 4.1. The standard production, or optimum performance for these pieces of equipment are shown in Table B.10. This production rate reflects the work that can be expected from a unit performing a task such as moving a uniform gravel from a stockpile with no space restrictions. This standard production must be adjusted for decrease in capacity due to such things as large non-uniform fragment size. This adjustment varies with debris type and is shown in Table B.11.

Downward adjustments in machinery productivity results also from crowded working conditions. For example, the efficiency of each of two tractors, working in close proximity, will be less than that of either working alone without interference. The multiple unit problem does not apply to the current analysis but a similar problem does exist in the limited working space of the narrow clearing routes. The effect of multi-unit operation on production is shown for reference only in Table B.12, and is taken from Reference 2.

The above tables have been used as guidelines to prepare a table of production rates for the equipment allocated to the hypothetical zones. The adjusted production rates for each condition are shown on Table 6.1 which also indicates some of the factors used to achieve them.

6.3 Debris Clearing Times - Results

All of the debris removal data for the individual hypothetical

EQUIPMENT ASSIGNED ZONE
PRODUCTION CAPACITY PER UNIT
ADJUSTED FOR SPACE AND ZONE DEBRIS TYPE

EQUIPMENT			PROD. ADJ. FOR SPACE	PRODUCTION BY ZONE			
Code	Qty.	Standard Prod.		3-2(T) .72(F)	2-3(T) .74(F)	3-3(T) .72(F)	4-3(T) .53(F)
141	2	160	145	105	105	105	75
160	1	100	90	65	65	65	50
161	1	130	115	85	85	85	60
162	3	140	125	90	90	90	65
163	2	185	165	120	120	120	90
165	1	250	225	160	160	160	120
167	1	330	300	215	215	215	160
280	2	140	125	90	90	90	65
284	2	330	300	215	215	215	160
286	2	400	360	260	260	260	190
288	1	520	470	340	340	340	250

(T) - Building Debris Type

(F) - Equipment Productivity factor for debris type modified by traffic inclusion factor from Table B.11.

TABLE 6.1

situations have been summarized on forms made for this analysis and called Task Evaluation Sheets. These twenty-four sheets are presented as Tables 6.4 through 6.27 inclusive and are found at the end of this section. An analysis was made on each sheet showing how many of the 16 hypothetical routes previously described could be cleared in three hours.

Each situation assumes use of the same typical distribution of equipment previously described so that results can be correlated and compared. This correlation will help in the concluding section of this report to generalize and simplify some of these procedures for more direct application in an emergency situation. It should be noted that Table 4.1 shows a total of 18 pieces of equipment assigned to the zone; 2 motorgraders, 7 crawler dozers, 4 crawler front end loaders and 5 wheeled front end loaders. Motorgraders are not suited for meandering path clearing through the odd size and shape fragments of building debris, so it is assumed that these units are used to keep open routes previously cleared by the other equipment. Although the wheeled front end loaders can maneuver over debris to some extent, the situations requiring multiple units in a "leap-frog" operation will be the most difficult. It will be assumed for this study that only one wheeled unit (starting at the MSA) will be used on any one route in a multiple unit operation.

A summary of the route clearing capacities for all situations is given in Table 6.2. These results show the following:

1. At 2 psi there will be no debris clearing problem for any of the zones.

SUMMARY OF DEBRIS CLEARING CAPABILITY

ZONE	OVER-PRESSURE	ROUTE DEPTH	TOTAL CLEARED IN 3 HRS.		
			No. Routes	Feet	Miles
1 Wood Frame 30' High	2	-	16+	236,000+	44.7+
	4	0.05	16+	236,000+	44.7+
	6	0.17	6	92,100	17.4
	10	0.57	1	27,700	5.2
2 Wood Frame 50' High	2	-	16+	236,000+	44.7+
	4	0.09	11	174,900	33.1
	6	0.28	4	55,600	10.5
	10	0.94	1	15,900	3.0
3 Masonry 50' High	2	-	16+	236,000+	44.7+
	4	-	16+	236,000+	44.7+
	6	0.04	16+	236,000+	44.7+
	10	1.63	0	8,700	1.6
4 Masonry 50' High	2	-	16+	236,000+	44.7+
	4	-	16+	236,000+	44.7+
	6	0.21	5	75,000	14.2
	10	6.24	0	1,690	0.3
5 Reinf. Conc. 100' High	2	-	16+	236,000+	44.7+
	4	0.21	5	75,000	14.2
	6	1.78	0	7,900	1.5
	10	16.77	0	320	0.1
6 Steel Frame 200' High	2	-	16+	236,000+	44.7+
	4	0.22	5	71,600	13.6
	6	1.31	0	8,200	1.6
	10	5.24	0	1,590	0.3

Note: Maximum number of tasks set for this study is 16 routes. Where equipment capabilities exceed this it is indicated as 16+. See individual Task Evaluation Sheets for additional details.

TABLE 6.2

2. At 4 psi most or all of the expected emergency routes can be cleared in 3 hours in the single family and townhouse areas. In the high rise areas more than 70,000 feet of route can be cleared or about 5 complete routes in each.

3. At 6 psi a few routes can be cleared in single family areas but none would be completed in the high rise areas.

4. At 10 psi the situation is very bad with about one route cleared in single family areas but only a thousand feet or less in the high rise areas.

The three hour route clearance task sheets show a wide range of results for the situations considered. In order to complete this picture a supplementary table has been prepared for the eight situations where one or less routes can be completed in three hours. Table 6.3 shows the length of time necessary to complete four separate route tasks for each of the eight cases, using all available appropriate equipment. The tasks shown include single routes, indicating the shortest (Route 1) and longest (Route 13) distances required to reach the outskirts of the zone. Task times are also given for double routes indicating the shortest (Routes 1 & 3) and longest (Routes 13 & 15) distances across the zone which would be required for interzone travel and rescue work.

The 24 situations chosen for this study can be divided into three categories based on Tables 6.2 and 6.3. A majority of 16 zone and

TIME REQUIRED FOR MINIMUM ROUTE TASKS FOR ZONE SITUATIONS REQUIRING MORE THAN THREE HOURS

ZONE	OVER-PRESSURE	ROUTE DEBRIS DEPTH	COMBINED DISTANCE CLEARED PER HOUR		NO. OF HOURS REQ'D PER TASK			
					SINGLE ROUTE		INTERZONE ROUTE	
			12 Units	13 Units	Rt 1 Only	Rt 13 Only	Rts 1 & 3	Rts 13 & 15
1	10	0.57	6,800	7,400	3*	3	4	6
2	10	0.94	4,100	4,300	3	5	6	10
3	10	1.63	2,230	2,430	6	9	11	17
4	10	6.24	440	470	30	46	56	85
5	6	1.78	2,030	2,200	7	10	12	19
	10	16.77	80	90	163	250	289	445
6	6	1.31	2,100	2,300	7	10	12	18
	10	5.24	410	450	32	49	58	89

Note: Single routes are cleared using 11 crawler units and 1 wheeled unit and Interzone routes using 11 crawler units and 2 wheeled units except as noted.

*Task accomplished with 6 units (See Table 6.7)

TABLE 6.3

overpressure situations permit clearing of four to sixteen single lane emergency routes within three hours considering the conditions and use of equipment previously defined. This would permit access to the most critical points within the zone or routes across the zone for interzone travel. The second category includes 5 situations where any one of the four minimum tasks defined for Table 6.3 could be performed in less than 24 hours. The three remaining situations in the third category are 10 psi overpressure for zones 4, 5, and 6 and require from 30 to 250 hours clearing a single route, or 56 to 445 hours for one interzone route.

It is obvious that use of any surviving personnel and equipment in the third category situation would be wasted on trying to clear paths during the three hour period. Any planned interzone routes would have to bypass these zones and rescue and fire fighting within the zone would have to be done by helicopter or by climbing over the debris with the crawler construction equipment.

In the second category it is probable that, as in category three, the equipment would be more useful in direct rescue work than in clearing paths. Once this initial phase is passed decisions would have to be made on interzone priority clearing operations. At this later stage it might be decided to bypass some zones and redeploy equipment to concentrate on the most critical interzone routes.

TASK EVALUATION SHEET - DEBRIS

Zone No. 1 Ov. Pr. PSI 2 % Cov. Bldgs. 20

General Description: Sngl. family 1-story frame residences on norm. city lots.

Building: Type 1 Height 30 Use RES

Debris Type NONE

Street Width 80

Rt. Width	10	12	14	16
Deb/1000 ft.	0	0	0	0

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds.				Lin. Ft./3 Hrs. (1000ft.)	
				Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Per Unit	Cumul. All Units
		NEGLI	GIBLE	DEBRIS	IN	STREETS			

TABLE 6.4

TASK EVALUATION SHEET - DEBRIS

Zone No. 1 Ov. Pr. PSI 4 % Cov. Bldgs. 20

General Description: Sngl. family 1-story frame residences on norm. city lots.

Building: Type 1 Height 30 Use RES

Debris Type 3 - 2

Street Width 80

Rt. Width	10	12	14	16
Deb/1000 ft.	18	22	26	30

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds. Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Lin. Ft./3 Hrs. (1000 ft.) Per Unit	Cumul. All Units
1	18	163	10	185	165	120	360	20.0	20.0
2	18	161	10	130	115	85	255	14.2	14.2
3	22	165	12	250	225	160	480	21.8	21.8
4	18	163	10	185	165	120	360	20.0	20.0
5	22	280	12	140	125	90	270	12.3	12.3
6	18	162	10	140	125	90	270	15.0	15.0
7	18	162	10	140	125	90	270	15.0	15.0
8	26	284	14	330	300	215	645	24.8	24.8
9	18	160	10	100	90	65	195	10.8	10.8
10	22	280	12	140	125	90	270	12.3	12.3
11	26	284	14	330	300	215	645	24.8	24.8
12	18	162	10	140	125	90	270	15.0	15.0
13	22	167	12	330	300	215	645	29.3	29.3
14	30	288	16	520	470	340	1020	34.0	34.0
15	30	286	16	400	360	260	780	26.0	26.0
16	30	286	16	400	360	260	780	26.0	26.0
								Total	321.3

NOTES: Under-capacities at Route 5 to be supplemented from 1; 9 from 8; and 10 from 11. All routes can be completed.

TABLE 6.5

TASK EVALUATION SHEET - DEBRIS

Zone No. 1 Ov. Pr. PSI 6 % Cov. Bldgs. 20

General Description: Sngl. family 1-story frame residences on city lots.

Building: Type 1 Height 30 Use RES

Debris Type 3 - 2

Street Width 80

Rt. Width	10	12	14	16
Deb/1000 ft.	64	77	89	103

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds.				Lin. Ft./3 Hrs. (1000 ft.	
				Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Per Unit	Cumul. All Units
1	103 64	288 163	16 10	520 185	470 165	340 120	1020 360	9.9 5.6	9.9 15.5
2	103 64	286 163	16 10	400 185	360 165	260 120	780 360	7.6 5.6	7.6 13.2
3	89 77	284 167	14 12	330 330	300 300	215 215	645 645	7.3 8.4	7.3 15.7
4	77 77 64 64	280 280 162 162	12 12 10 10	140 140 140 140	125 125 125 125	90 90 90 90	270 270 270 270	3.5 3.5 4.2 4.2	3.5 7.0 11.2 15.4
5	89 103	284 286	14 16	330 400	300 360	215 260	645 780	7.3 7.6	7.3 14.9
6	64 64 77	160 162 165	10 10 12	100 140 250	90 125 225	65 90 160	195 270 480	3.0 4.2 6.2	3.0 7.2 13.4
13	64	161	10	130	115	85	255	4.0	4.0*
*INCOMPLETE ROUTE								Total	92.1

TABLE 6.6

TASK EVALUATION SHEET - DEBRIS

Zone No. 1 Ov. Pr. PSI 10 % Cov. Bldgs. 20

General Description: Sngl. family 1-story frame residences on city lots.

Building: Type 1 Height 30 Use RES

Debris Type 3 - 2

Street Width 80

Rt. Width	10	12	14	16
Deb/1000 ft.	223	265	307	350

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds. Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Lin. Ft./3 Hrs. Per Unit	Cumul. All Units
1	350	288	16	520	470	340	1020	2.9	2.9
	350	286	16	400	360	260	780	2.2	5.1
	350	286	16	400	360	260	780	2.2	7.3
	307	284	14	330	300	215	645	2.1	9.4
	307	284	14	330	300	215	645	2.1	11.5
	265	165	12	250	225	160	480	1.8	13.3
2	265	280	12	140	125	90	270	1.0	1.0
	265	280	12	140	125	90	270	1.0	2.0
	265	167	12	330	300	215	645	2.4	4.4
	223	162	10	140	125	90	270	1.2	5.6
	223	162	10	140	125	90	270	1.2	6.8
	223	162	10	140	125	90	270	1.2	8.0
	223	160	10	100	90	65	195	0.9	8.9*
3	223	161	10	130	115	85	255	1.1	1.1*
4	265	163	10	250	225	160	480	2.2	2.2*
13	223	163	10	250	225	160	480	2.2	2.2*
* INCOMPLETE ROUTE								Total	27.7

NOTE: Route 2 not completed because remaining equipment is rubber tired and not appropriate for "leap frog" type route clearing.

TABLE 6.7

TASK EVALUATION SHEET - DEBRIS

Zone No. 2 Ov. Pr. PSI 2 % Cov. Bldgs. 20

General Description: 2-Story frame sngl. family residence on city lots.

Building: Type 1 Height 50 Use RES

Debris Type NONE

Street Width 80

Rt. Width	10	12	14	16
Deb/1000 ft.	0	0	0	0

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds. Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Lin. Ft./3 Hrs. (1000 ft.) Per Unit	Cumul. All Units
		NEGLI	GIBLE	DEBRIS	IN	STREETS			

TABLE 6.8

TASK EVALUATION SHEET - DEBRIS

Zone No. 2 Ov. Pr. PSI 4 % Cov. Bldgs. 20

General Description: 2-Story frame sngl. family residence on city lots.

Building: Type 1 Height 50 Use RES

Debris Type 3 - 2

Street Width 80

Rt. Width	10	12	14	16
Deb/1000 ft.	34	40	47	54

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds.				Lin. Ft./3 Hrs. (1000 ft.)	
				Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Per Unit	Cumul. All Units
1	34 34	160 163	10 10	100 185	90 165	65 120	195 360	5.7 10.6	5.7 16.3
2	34 34	161 162	10 10	130 140	115 125	85 90	255 270	7.5 7.9	7.5 15.4
3	34 40	163 280	10 12	185 140	165 125	120 90	360 270	10.6 6.8	10.6 17.4
4	40 40	165 280	12 12	250 140	225 125	160 90	480 270	12.0 6.8	12.0 18.8
5	34 34	162 162	10 10	140 140	125 125	90 90	270 270	7.9 7.9	7.9 15.8
6	40	167	12	330	300	215	645	16.1	16.1
7	47	284	14	330	300	215	645	13.7	13.7
8	47	284	14	330	300	215	645	13.7	13.7
9	54	286	16	400	360	260	780	14.4	14.4
10	54	286	16	400	360	260	780	14.4	14.4
11	54	288	16	520	470	340	1020	18.9	18.9
								Total	174.9

TABLE 6.9

TASK EVALUATION SHEET - DEBRIS

Zone No. 2 Ov. Pr. PSI 6 % Cov. Bldgs. 20

General Description: 2-Story sngl. family residences on city lots.

Building: Type 1 Height 50 Use RES

Debris Type 3 - 2

Street Width 80

Rt. Width	10	12	14	16
Deb/1000 ft.	107	127	148	169

				Equip. Cap. - Cu. Yds.				Lin. Ft./3 Hrs. (1000 ft.)	
Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Per Unit	Cumul. All Units
1	169	288	16	520	470	340	1020	6.0	6.0
	169	286	16	400	360	260	780	4.6	10.6
	127	165	12	250	225	160	480	3.8	14.4
2	169	286	16	400	360	260	780	4.6	4.6
	148	284	14	330	300	215	645	4.4	9.0
	127	167	12	330	300	215	645	5.1	14.1
3	148	284	14	330	300	215	645	4.4	4.4
	107	163	10	185	165	120	360	3.4	7.8
	127	280	12	140	125	90	270	2.1	9.9
	127	280	12	140	125	90	270	2.1	12.0
	107	160	10	100	90	65	195	1.8	13.8
4	107	162	10	140	125	90	270	2.5	2.5
	107	162	10	140	125	90	270	2.5	5.0
	107	162	10	140	125	90	270	2.5	7.5
	107	163	10	185	165	120	360	3.4	10.9
	107	161	10	130	115	85	255	2.4	13.3
								Total	55.6

TABLE 6.10

TASK EVALUATION SHEET - DEBRIS

Zone No. 2 Ov. Pr. PSI 10 % Cov. Bldgs. 20

General Description: 2-Story sngl. family residences on city lots.

Building: Type 1 Height 50 Use RES

Debris Type 3 - 2

Street Width 80

Rt. Width	10	12	14	16
Deb/1000 ft.	380	450	519	589

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds. Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Lin.Ft./3 Hrs. (1000 ft.) Per Unit	Cumul. All Units
1	589	288	16	520	470	340	1020	1.7	1.7
	589	286	16	400	360	260	780	1.3	3.0
	589	286	16	400	360	260	780	1.3	4.3
	450	284	14	330	300	215	645	1.4	5.7
	450	284	14	330	300	215	645	1.4	7.1
	450	280	12	140	125	90	270	0.6	7.7
	450	280	12	140	125	90	270	0.6	8.3
	450	167	12	330	300	215	645	1.4	9.7
	380	162	10	140	125	90	270	0.7	10.4
	380	162	10	140	125	90	270	0.7	11.1
	380	162	10	140	125	90	270	0.7	11.8
	380	160	10	100	90	65	195	0.5	12.3
	380	161	10	130	115	85	255	0.7	13.0
2	450	165	12	250	225	160	480	1.1	1.1*
3	380	163	10	185	165	120	360	0.9	0.9*
4	380	163	10	185	165	120	360	0.9	0.9*
*INCOMPLETE ROUTE								Total	15.9

TABLE 6.11

TASK EVALUATION SHEET - DEBRIS

Zone No. 3 Ov. Pr. PSI 2 % Cov. Bldgs. 20

General Description: 2-Story sngl. family masonry const. on city lots.

Building: Type 2 Height 50 Use RES

Debris Type NONE

Street Width 80

Rt. Width	10	12	14	16
Deb/1000 ft.	0	0	0	0

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds.				Lin. Ft./3 Hrs. (1000 ft.)	
				Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Per Unit	Cumul. All Units
		NEGLI	GIBLE	DEBRIS	IN	STREETS			

TABLE 6.12

TASK EVALUATION SHEET - DEBRIS

Zone No. 3 Ov. Pr. PSI 4 % Cov. Bldgs. 20

General Description: 2-Story sngl. family masonry construction on city lots.

Building: Type 2 Height 50 Use RES

Debris Type NONE

Street Width 80

Rt. Width	10	12	14	16
Deb/1000 ft.	0	0	0	0

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds. Stand Per Hr.	Equip. Cap. - Cu. Yds. Adj. Space	Equip. Cap. - Cu. Yds. Adj. Debris	Equip. Cap. - Cu. Yds. Net 3 Hrs.	Lin. Ft./3 Hrs. (1000 ft.) Per Unit	Lin. Ft./3 Hrs. (1000 ft.) Cumul. All Units
		NEGLIGIBLE DEBRIS IN STREETS							

TABLE 6.13

TASK EVALUATION SHEET - DEBRIS

Zone No. 3 Ov. Pr. PSI 6 % Cov. Bldgs. 20

General Description: 2-Story sngl. family masonry houses on city lots.

Building: Type 2 Height 50 Use RES

Debris Type 3 - 2

Street Width 80

Rt. Width	10	12	14	16
Deb/1000 ft.	15	18	21	24

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds. Stand Per Hr.	Equip. Cap. - Cu. Yds. Adj. Space	Equip. Cap. - Cu. Yds. Adj. Debris	Equip. Cap. - Cu. Yds. Net 3 Hrs.	Lin.Ft./3 Hrs. (1000 ft.) Per Unit	Lin.Ft./3 Hrs. (1000 ft.) Cumul. All Units
1	15	160	10	100	90	65	195	13.0	13.0
2	15	161	10	130	115	85	255	17.0	17.0
3	15	162	10	140	125	90	270	18.0	18.0
4	15	162	10	140	125	90	270	18.0	18.0
5	15	162	10	140	125	90	270	18.0	18.0
6	15	163	10	185	165	120	360	24.0	24.0
7	15	163	10	185	165	120	360	24.0	24.0
8	18	165	12	250	225	160	480	26.7	26.7
9	18	167	12	330	300	215	645	35.8	35.8
10	18	280	12	140	125	90	270	15.0	15.0
11	18	280	12	140	125	90	270	15.0	15.0
12	21	284	14	330	300	215	645	30.7	30.7
13	21	284	14	330	300	215	645	30.7	30.7
14	24	286	16	400	360	260	780	32.5	32.5
15	24	286	16	400	360	260	780	32.5	32.5
16	24	288	16	520	470	340	1020	42.5	42.5
								Total	393.4

TABLE 6.14

TASK EVALUATION SHEET - DEBRIS

Zone No. 3 Ov. Pr. PSI 10 % Cov. Bldgs. 20

General Description: 2-Story sngl. family masonry residences on city lots.

Building: Type 2 Height 50 Use RES

Debris Type 3 - 2

Street Width 80

Rt. Width	10	12	14	16
Deb/1000 ft.	702	822	943	1063

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds. Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Lin. Ft./3 Hrs. (1000 ft.) Per Unit	Cumul. All Units
1	1063	288	16	520	470	340	1020	1.0	1.0
	1063	286	16	400	360	260	780	0.7	1.7
	1063	286	16	400	360	260	780	0.7	2.4
	943	284	14	330	300	215	645	0.7	3.1
	943	284	14	330	300	215	645	0.7	3.8
	822	280	12	140	125	90	270	0.3	4.1
	822	280	12	140	125	90	270	0.3	4.4
	702	162	10	140	125	90	270	0.4	4.8
	702	162	10	140	125	90	270	0.4	5.2
	702	162	10	140	125	90	270	0.4	5.6
	702	160	10	100	90	65	195	0.3	5.9
	822	167	12	330	300	215	645	0.8	6.7*
	NO MORE CRAWLERS 52% OF 13000 FT. OR 6700 FT. COMPLETE								
2	822	165	12	250	225	160	480	0.6	0.6*
3	702	163	10	185	165	120	360	0.5	0.5*
4	702	163	10	185	165	120	360	0.5	0.5*
13	702	161	10	130	115	85	255	0.4	0.4*
*ALL INCOMPLETE (SEE TEXT)								Total	8.7

TABLE 6.15

TASK EVALUATION SHEET - DEBRIS

Zone No. 4 Ov. Pr. PSI 2 % Cov. Bldgs. 50

General Description: 2-Story masonry town house construction on street line.

Building: Type 2 Height 50 Use RES

Debris Type NONE

Street Width 60

Rt. Width	10	12	14	16
Deb/1000 ft.	0	0	0	0

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds. Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Lin.Ft./3 Hrs. (1000 ft.) Per Unit	Cumul. All Units
		NEGLI	GIBLE	DEBRIS	IN	STREETS			

TABLE 6.16

TASK EVALUATION SHEET - DEBRIS

Zone No. 4 Ov. Pr. PSI 4 % Cov. Bldgs. 50

General Description: 2-Story masonry town house construction on street line.

Building: Type 2 Height 50 Use RES

Debris Type NONE

Street Width 60

Rt. Width	10	12	14	16
Deb/1000 ft.	0	0	0	0

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds.				Lin. Ft./3 Hrs. (1000 ft.)	
				Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Per Unit	Cumul. All Units
		NEGLIGIBLE DEBRIS IN STREETS							

TABLE 6.17

TASK EVALUATION SHEET - DEBRIS

Zone No. 4 Ov. Pr. PSI 6 % Cov. Bldgs. 50

General Description: 2-Story masonry town house residential const. on street line.

Building: Type 2 Height 50 Use RES

Debris Type 3 - 2

Street Width 60

Rt. Width	10	12	14	16
Deb/1000 ft.	79	95	110	125

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds.				Lin. Ft./3 Hrs. (1000 ft.)	
				Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Per Unit	Cumul. All Units
1	125 95	288 165	16 12	520 250	470 225	340 160	1020 480	8.2 5.1	8.2 13.3
2	125 95	286 167	16 12	400 330	360 300	260 215	780 645	6.2 6.8	6.2 13.0
3	125 79 79 79	286 161 162 162	16 10 10 10	400 130 140 140	360 115 125 125	260 85 90 90	780 255 270 270	6.2 3.2 3.4 3.4	6.2 9.4 12.8 16.2
4	110 79 79	284 163 162	14 10 10	330 185 140	300 165 125	215 120 90	645 360 270	5.9 4.6 3.4	5.9 10.5 13.9
5	110 95 95 79	284 280 280 160	14 12 12 10	330 140 140 100	300 125 125 90	215 90 90 65	645 270 270 195	5.9 2.8 2.8 2.5	5.9 8.7 11.5 14.0
13	79	163	10	185	165	120	360	4.6	4.6*
*INCOMPLETE ROUTE								Total	75.0

TABLE 6.18

TASK EVALUATION SHEET - DEBRIS

Zone No. 4 Ov. Pr. PSI 10 % Cov. Bldgs. 50

General Description: 2-Story masonry tn.-hse. type const. on street line.

Building: Type 2 Height 50 Use RES

Debris Type 3 - 2

Street Width 60

Rt. Width	10	12	14	16
Deb/1000 ft.	3750	4200	4650	5150

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds. Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Lin.Ft./3 Hrs. (1000 ft.) Per Unit	Cumul. All Units
1	5150	288	16	520	470	340	1020	0.20	0.20
	5150	286	16	400	360	260	780	0.15	0.35
	5150	286	16	400	360	260	780	0.15	0.50
	4650	284	14	330	300	215	645	0.14	0.64
	4650	284	14	330	300	215	645	0.14	0.78
	4200	280	12	140	125	90	270	0.06	0.84
	4200	280	12	140	125	90	270	0.06	0.90
	3750	162	10	140	125	90	270	0.07	0.97
	3750	162	10	140	125	90	270	0.07	1.04
	3750	162	10	140	125	90	270	0.07	1.11
	3750	160	10	100	90	65	195	0.05	1.16
	4200	167	12	330	300	215	645	0.15	1.31*
	NOT COMPLETE ONLY 1310 FT. "CLEARED" - SEE TEXT.								
2	4200	165	12	250	225	160	480	0.11	0.11*
3	3750	163	10	185	165	120	360	0.10	0.10*
4	3750	163	10	185	165	120	360	0.10	0.10*
13	3750	161	10	130	115	85	255	0.07	0.07*
*ALL INCOMPLETE								Total	1.69

TABLE 6.19

TASK EVALUATION SHEET - DEBRIS

Zone No. 5 Ov. Pr. PSI 2 % Cov. Bldgs. 70

General Description: Multi-story apt. reinforced conc. or steel frm. with msnry. exterior panels.

Building: Type 14 Height 100 Use RES

Debris Type None

Street Width 60

Rt. Width	10	12	14	16
Deb/1000 ft.	0	0	0	0

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds.				Lin. Ft./3 Hrs. (1000 ft.)	
				Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Per Unit	Cumul. All Units
NEGLIGIBLE DEBRIS IN STREETS									

TABLE 6.20

TASK EVALUATION SHEET - DEBRIS

Zone No. 5 Ov. Pr. PSI 4 % Cov. Bldgs. 70

General Description: Multi-Story apt, reinfrcd. conc. or steel frm. with msnry. exterior panels.

Building: Type 14 Height 100 Use RES.

Debris Type 2 - 3

Street Width 60

Rt. Width	10	12	14	16
Deb/1000 ft.	79	95	110	125

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds. Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Lin. Ft./3 Hrs. (1000 ft.) Per Unit	Cumul. All Units
1	125 95	288 165	16 12	520 250	470 225	340 160	1020 480	8.2 5.1	8.2 13.3
2	125 79 79	286 163 160	16 10 10	400 185 100	360 165 90	260 120 65	780 360 195	6.2 4.6 2.5	6.2 10.8 13.3
3	125 95 79	286 280 163	16 12 10	400 140 185	360 125 165	260 90 120	780 270 360	6.2 2.8 4.6	6.2 9.0 13.6
4	110 95 95	284 280 167	14 12 12	330 140 330	300 125 300	215 90 215	645 270 645	5.9 2.8 6.8	5.9 8.7 15.5
5	79 79 79 110	162 162 162 284	10 10 10 14	140 140 140 330	125 125 125 300	90 90 90 215	270 270 270 645	3.4 3.4 3.4 5.9	3.4 6.8 10.2 16.1
13	79	161	10	130	115	85	255	3.2	3.2*
*INCOMPLETE ROUTE								Total	75.0

TABLE 6.21

TASK EVALUATION SHEET - DEBRIS

Zone No. 5 Ov. Pr. PSI 6 % Cov. Bldgs. 70

General Description: Multi-story apt. reinfrcd. conc. or steel frame with masonry exterior panels.

Building: Type 14 Height 100 Use RES

Debris Type 3 - 3

Street Width 60

Rt. Width	10	12	14	16
Deb/1000 ft.	775	905	1040	1170

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds. Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Lin. Ft./3 Hrs. (1000 ft.) Per Unit	Cumul. All Units
1	1170	288	16	520	470	340	1020	0.9	0.9
	1170	286	16	400	360	260	780	0.7	1.6
	1170	286	16	400	360	260	780	0.7	2.3
	1040	284	14	330	300	215	645	0.6	2.9
	1040	284	14	330	300	215	645	0.6	3.5
	905	280	12	140	125	90	270	0.3	3.8
	905	280	12	140	125	90	270	0.3	4.1
	775	162	10	140	125	90	270	0.3	4.4
	775	162	10	140	125	90	270	0.3	4.7
	775	162	10	140	125	90	270	0.3	5.0
	775	160	10	100	90	65	195	0.3	5.3
	775	167	10	330	300	215	645	0.8	6.1*
	NO MORE CRAWLERS 47% OF 13000 FT. OR 6100 FT. COMPLETE								
2	905	165	12	250	225	160	480	0.5	0.5*
3	775	163	10	185	165	120	360	0.5	0.5*
4	775	163	10	185	165	120	360	0.5	0.5*
13	775	161	10	130	115	85	255	0.3	0.3*
*ALL INCOMPLETE (SEE TEXT)								Total	7.9

TABLE 6.22

TASK EVALUATION SHEET - DEBRIS

Zone No. 5 Ov. Pr. PSI 10 % Cov. Bldgs. 70

General Description: Multi-story apt. reinf. co , or steel frame with masonry ~~exterior panels.~~

Building: Type 14 Height 100 Use RES

Debris Type 4 - 3

Street Width 60

Rt. Width	10	12	14	16
Deb/1000 ft.	16,610	17,851	19,092	20,333

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds. Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Lin.Ft./3 Hrs. (1000 ft.) Per Unit	Cumul. All Units
1	20333	288	16	520	470	250	750	0.04	0.04
	20333	286	16	400	360	190	570	0.03	0.07
	20333	286	16	400	360	190	570	0.03	0.10
	19092	284	14	330	300	160	480	0.03	0.13
	19092	284	14	330	300	160	480	0.03	0.16
	17851	280	12	140	125	65	195	0.01	0.17
	17851	280	12	140	125	65	195	0.01	0.18
	16610	162	10	140	125	65	195	0.01	0.19
	16610	162	10	140	125	65	195	0.01	0.20
	16610	162	10	140	125	65	195	0.01	0.21
	16610	160	10	100	90	50	150	0.01	0.22
	17851	167	12	330	300	160	480	0.03	0.25*
	NOT COMPLETE ONLY 250 FT. "CLEARED"-SEE NOTE BELOW								
2	17851	165	12	250	225	120	360	0.02	0.02*
3	16610	163	10	185	165	90	270	0.02	0.02*
4	16610	163	10	185	165	90	270	0.02	0.02*
13	16610	161	10	130	115	60	180	0.01	0.01*
*ALL INCOMPLETE								Total	0.32

NOTE: This is theoretical solution to problem but in fact cannot be done in three hours, as distances "cleared" in most cases are less than the length of the piece of equipment. See text for more complete discussion on this situation.

TABLE 6.23

TASK EVALUATION SHEET - DEBRIS

Zone No. 6 Ov. Pr. PSI 2 % Cov. Bldgs. 70

General Description: Multi-story reinfrcd. conc. shearwall - msnry. interior panels.

Building: Type 11 Height 200 Use RES

Debris Type None

Street Width 60

Rt. Width	10	12	14	16
Deb/1000 ft.	0	0	0	0

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds.				Lin. Ft./3 Hrs. (1000 ft.)	
				Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Per Unit	Cumul. All Units
		NEGLIGIBLE DEBRIS IN STREETS							

TABLE 6.24

TASK EVALUATION SHEET - DEBRIS

Zone No. 6 Ov. Pr. PSI 4 % Cov. Bldgs. 70

General Description: Multi-story reinfrcd. conc. shearwall msnry. interior panels.

Building: Type 11 Height 200 Use RES

Debris Type 3 - 3

Street Width 60

Rt. Width	10	12	14	16
Deb/1000 ft.	83	99	115	131

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds.				Lin.Ft./3 Hrs. (1000 ft.)	
				Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Per Unit	Cumul. All Units
1	131	288	16	520	470	340	1020	7.8	7.8
	99	165	12	250	225	160	480	4.8	12.6
	99	280	12	140	125	90	270	2.7	15.3
2	99	167	12	330	300	215	645	6.5	6.5
	83	160	10	100	90	65	195	2.3	8.8
	115	284	14	330	300	215	645	5.6	14.4
3	131	286	16	400	360	260	780	6.0	6.0
	83	162	10	140	125	90	270	3.3	9.3
	83	161	10	130	115	85	255	3.1	12.4
	99	280	12	140	125	90	270	2.7	15.1
4	115	284	14	330	300	215	645	5.6	5.6
	83	162	10	140	125	90	270	3.3	8.9
	83	163	10	185	165	120	360	4.3	13.2
5	83	162	10	140	125	90	270	3.3	3.3
	131	286	16	400	360	260	780	6.0	9.3
	83	163	10	185	165	120	360	4.3	13.6
								Total	71.6

TABLE 6.25

TASK EVALUATION SHEET - DEBRIS

Zone No. 6 Ov. Pr. PSI 6 % Cov. Bldgs. 70

General Description: Multi-story reinfrcd. conc. shearwall msnry. interior panels.

Building: Type 11 Height 200 Use RES

Debris Type 4 - 3

Street Width 60

Rt. Width	10	12	14	16
Deb/1000 ft.	548	645	740	839

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds. Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Lin. Ft./3 Hrs. (1000 ft.) Per Unit	Cumul. All Units
1	839	288	16	520	470	250	750	0.9	0.9
	839	283	16	400	360	190	570	0.7	1.6
	839	286	16	400	360	190	570	0.7	2.3
	740	284	14	330	300	160	480	0.6	2.9
	740	284	14	330	300	160	480	0.6	3.5
	645	280	12	140	125	65	195	0.3	3.8
	645	280	12	140	125	65	195	0.3	4.1
	548	162	10	140	125	65	195	0.4	4.5
	548	162	10	140	125	65	195	0.4	4.9
	548	162	10	140	125	65	195	0.4	5.3
	548	160	10	100	90	50	150	0.3	5.6
	645	167	12	330	300	160	480	0.7	6.3*
	NO MORE CRAWLERS 48% OF 13000 FT. OR 6300 FT. COMPLETE								
2	645	165	12	250	225	120	360	0.6	0.6*
3	548	163	10	185	165	90	270	0.5	0.5*
4	548	163	10	185	165	90	270	0.5	0.5*
5	548	161	10	130	115	60	180	0.3	0.3*
*ALL INCOMPLETE (SEE TEXT)								Total	8.2

TABLE 6.26

TASK EVALUATION SHEET - DEBRIS

Zone No. 6 Ov. Pr. PSI 10 % Cov. Bldgs. 70

General Description: Multi-story reinf. conc. shearwall masonry int. panels

Building: Type 11 Height 200 Use RES

Debris Type 4 - 3

Street Width 60

Rt. Width	10	12	14	16
Deb/1000 ft.	2955	3343	3730	4119

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds.				Lin.Ft./3 Hrs. (1000 ft.)	
				Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Per Unit	Cumul. All Units
1	4119	288	16	520	470	250	750	0.18	0.18
	4119	286	16	400	360	190	570	0.14	0.32
	4119	286	16	400	360	190	570	0.14	0.46
	3730	284	14	330	300	160	480	0.13	0.59
	3730	284	14	330	300	160	480	0.13	0.72
	3343	280	12	140	125	65	195	0.06	0.78
	3343	280	12	140	125	65	195	0.06	0.84
	2955	162	10	140	125	65	195	0.07	0.91
	2955	162	10	140	125	65	195	0.07	0.98
	2955	162	10	140	125	65	195	0.07	1.05
	2955	160	10	100	90	50	150	0.05	1.10
	3343	167	12	330	300	160	480	0.14	1.24*
	NOT COMPLETE ONLY 1240 FT. "CLEARED" - SEE TEXT								
2	3343	165	12	250	225	120	360	0.11	0.11*
3	2955	163	10	185	165	90	270	0.09	0.09*
4	2955	163	10	185	165	90	270	0.09	0.09*
13	2955	161	10	130	115	60	180	0.06	0.06*
	*ALL INCOMPLETE							Total	1.59

TABLE 5.27

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Metropolitan areas will have enough excavation equipment and personnel resources to clear rescue routes through debris in many emergency situations in predominantly single family residential areas. Few or no routes could be cleared in high density areas subjected to more than 6 psi overpressure.

The first few hours after the event will be the most critical, not only because there will be injuries and other needs for rescue, but also because early completion of access routes would provide fire breaks thereby preventing or containing subsequent fires which could be more damaging than the initial blast force. The work in this study showed that not only could much be accomplished in three hours in single family residential areas, but that significant debris removal progress could be expected under certain conditions in high rise areas.

For successful and effective operations it is necessary that resources be mobilized in the pre-event period. This will require some form of early warning and advance planning of resources and potential debris situations.

The most important equipment for this emergency type of work is tractors equipped either as bulldozers or as front end loaders. Crawler types are more versatile but there is an increasing number of the wheeled types being used. Their reliability is improving even for the moderately rough terrain such as would be represented by climbing over small quantities of debris for "leap-frog" operations.

The equipment inventories made to date indicate that in each large metropolitan area there should be available one 150 to 300 HP tractor for every three square miles of general area. This makes it possible to supply one tractor for about each square mile which appears to be the requirement for emergency debris removal in a moderately dense to densely populated section of such an urban area.

The above means the possible mobilization of 150 to 200 dozers or front end loaders, for each large city, or 10 to 20 tractors to each of 10 to 20 emergency zones. One problem is that the pre-event distribution of the equipment in most cases will be much less than ideal. This type of equipment is bulky and requires considerable space for storage and maintenance, though it is readily transportable. These combinations of features and other considerations in most cases lead to storage areas being located on the edge of the built up areas within a city. In addition, the storage yards frequently are concentrated in one area so that to mobilize on the opposite side of the city may require an hour or two under the best conditions to move up to 20 miles. This equipment has bulldozer blades or loading buckets of 9 to 16 feet in width so that one pass will clear a route for one way traffic.

There should be enough qualified personnel in any area to accomplish the debris removing activity. This includes management, administrative and operating personnel in all categories. A list should be compiled showing places to contact them. It is desirable to have this list updated periodically as some of this type of personnel is subject to frequent moves to follow construction activity.

It can also be concluded that it is essential that a detailed plan be drawn up to be used as guidelines by cities. Much of the debris estimates and equipment capacity figures will have to be generalized in order to make this plan simple and workable.

7.2 Recommendations

It is recommended that a simplified debris removal instruction be provided. This will be a guide to city or other urban-local jurisdiction which will plan and implement rescue efforts following a debris generating event.

The debris removal guide will eliminate as many variables as possible in debris potential evaluation and in the analyses of the capacity and mobilization of the resources. For example:

1 - Some 20 different types of building construction have been used for classification. There is not enough difference in debris generating potential in each of those types to require their use in debris estimates and it is a very complicated task to determine accurately the details of construction in older parts of cities.

2 - A contractor in planning a construction job can in many cases predict or control the environment in which his equipment will work. Consequently he can figure rather precisely the effects of each environmental variable to production. He can achieve maximum efficiency in matching the most suitable equipment to the various tasks required. In the urgent

operation of emergency debris removal there may be less of a choice of the exact equipment desired and less chance to control its environment. The degree of precision used in forecasting equipment performance in construction projects is therefore not warranted in debris removal prediction.

The above examples are only two of several rather complicated situations that must be simplified to avoid confusion and to assure that there is an effective emergency debris path clearance within a few hours after the debris is deposited. The more simple the instructions are made the greater are the possibilities that they will be used in both pre-event planning and post attack implementation.

The new debris removal instruction book should:

1 - Provide for a means to estimate street debris depth, volume and physical characteristics which are critical to its removal from an emergency path. The procedure must be fairly general in nature; flexible enough to accommodate variable situations yet provide realistic solutions.

2 - Indicate zone layout possibilities and ways to propose emergency route designs. The emergency path should be at least 10 feet wide but no wider than is essential to accommodate the equipment assigned to clear it.

3 - Show how to inventory resources and to estimate their capabilities.

4 - Provide detailed mobilization and operating instructions for operation in a three hour period following an emergency event.

5 - Give some simplified format for control of records of hours of personnel and of resources, such as hired equipment.

7.3 Example of Simplified Task Evaluation

One example of a method for simplifying some of these procedures is given in Table 7.1. It is based on the hypothetical situations used for this study. This table reduces the variables to determine equipment capabilities for a single meandering lane to route depth and debris type. The two general debris types found in the study zones are used. The same can be done for other types of debris, though it is likely that tables for two or three debris types, previously determined, will suffice for any particular zone. The depth of debris for meandering routes can also be predetermined for varying overpressures as outlined in Section 5. Once the event has occurred, however, the debris manager will know what overpressure the zone has been subjected to and can check the actual amount of debris in the streets.

Using the results obtained in this study and considering the sixteen pieces of equipment as representative, the route clearance capabilities of an "average" unit was established. The distance that this "average" unit could clear per hour could then be computed and presented in tabular form. The same was done for the smallest unit (code 160) and largest unit (code 288) considered in this study.

As an example, consider a task requiring a lane 13,000 feet long to be cleared in three hours. The debris is type 3-2 and 0.3 feet deep in the meandering lane. This can be accomplished by using: a) 3

SIMPLIFIED DEBRIS CLEARANCE TABLE

FOR EMERGENCY SINGLE LANE MEANDERING ROUTE

AVG. ROUTE DEPTH (FT.)	ROUTE DISTANCE CLEARED (FT.)/UNIT/HOUR					
	DEBRIS TYPES 2-3, 3-2, 3-3			DEBRIS TYPE 4-3		
	Smallest Unit	Average Unit	Largest Unit	Smallest Unit	Average Unit	Largest Unit
0.1	1700	3300	5700	1250	2450	4200
0.2	850	1650	2800	650	1200	2100
0.3	550	1100	1850	400	800	1400
0.4	400	800	1400	300	600	1000
0.5	350	650	1100	250	450	800
0.6	280	530	910	200	390	670
0.8	200	390	670	150	290	500
1.0	160	310	530	120	230	390
1.5	100	200	340	75	150	250
2.0	75	140	250	55	110	180
2.5	55	110	190	45	80	140
3.0	45	90	150	35	65	110
4.0	35	65	110	25	45	80
5.0	25	50	85	20	35	60

Note: The results obtained by use of this table are approximate and are intended for use in emergency situations to speed and simplify decisions in comparing capabilities and establishing priorities. When time permits, the procedures described in the text, incorporating all appropriate variables, should be followed.

TABLE 7.1

large units, $[13{,}000 \div (3 \times 1850)]$, b) 4 average size units, $[13{,}000 \div (3 \times 1100)]$, or, c) 8 small units, $[13{,}000 \div (3 \times 550)]$. If the depth to be cleared is 3 feet, it would take 48 average units $[13{,}000 \div (3 \times 90)]$ and probably not be possible. If only 16 units were available it would take 9 hours $[13{,}000 \div (16 \times 90)]$ to clear this route. This type of chart should be helpful in establishing relative priorities. It should be remembered, however, that it is based on average production rates of a particular mix of equipment and when time permits, the task evaluation based on the actual units available will yield more accurate answers.

APPENDIX A

DEBRIS REMOVAL

INSTRUCTIONS FOR IMPLEMENTATION AND EVALUATION

BACKGROUND

Immediately following several types of disasters, there will be a need to gain access to designated general areas of a city or to specific places for emergency vehicles such as ambulances, rescue cars and firetrucks. The instructions in this appendix are based on clearing emergency routes following an emergency caused by a nuclear explosion.

The guidelines provided here are designed primarily for use at the zone level within the city and coordination with some city wide or area actions are discussed. There may be ten to twenty zones within a city. Activity at the zone level is the key to determining the times which affect the critical survival actions or times required to gain access to critical spots. It is presumed for this analysis that the overall city plans for implementing debris removal have been made and only those which are critical to the zone debris problem are discussed here.

Some of the forms and tables have been used in other studies or in other portions of this report. They have been repeated in this Appendix where appropriate, to provide a complete and independent synopsis of debris removal planning procedures.

These instructions are based on the assumption that there will be a need to clear several routes within each zone in a city. These routes may be about two to three miles in length and wide enough for passage of one way traffic. It is assumed that in each route there will be some occasional wide spots for vehicle passing and these will occur naturally and not affect productivity or critical times.

It is further assumed that these routes must be cleared within a critical time of about three hours and within that time fires will not have spread sufficiently to interfere with debris removal activity or to modify the physical character of the debris. It is assumed also that radiation fallout is not a problem in this operation.

PRE-EVENT PLANNING

Plans should be made in as much detail as time and resources permit in anticipation of disasters, including nuclear explosions. The debris removal plan must be coordinated with other emergency efforts at the city levels. Familiarity with those other planned activities for the broader area is essential for the zone debris managers if they are to do their job well.

Establishing Zones

It is a common practice to divide a city into zones or areas of control of emergency operations. This is routine for fire departments, police control etc. If these have not been established for disaster recovery, the city debris removal planner should establish zone lines for his purpose. These can be used for his planning and should be made recognizing a probable need to later adjust them to coordinate with the other emergency plans.

The following features would be desirable for debris removal zones and resource control.

A - Be no more than 5 miles by 5 miles in size.

B - Contain all of the same type of building construction and size.

C - Have similar occupancy or use of buildings throughout.

D - Have facilities near the zone center for a staging area and zone command or control and resource marshalling position.

Such a hypothetical zone is shown on Figure A-1. The above listed zone features are for an ideal situation, which rarely will be found but the list can serve as a guide in establishing zones.

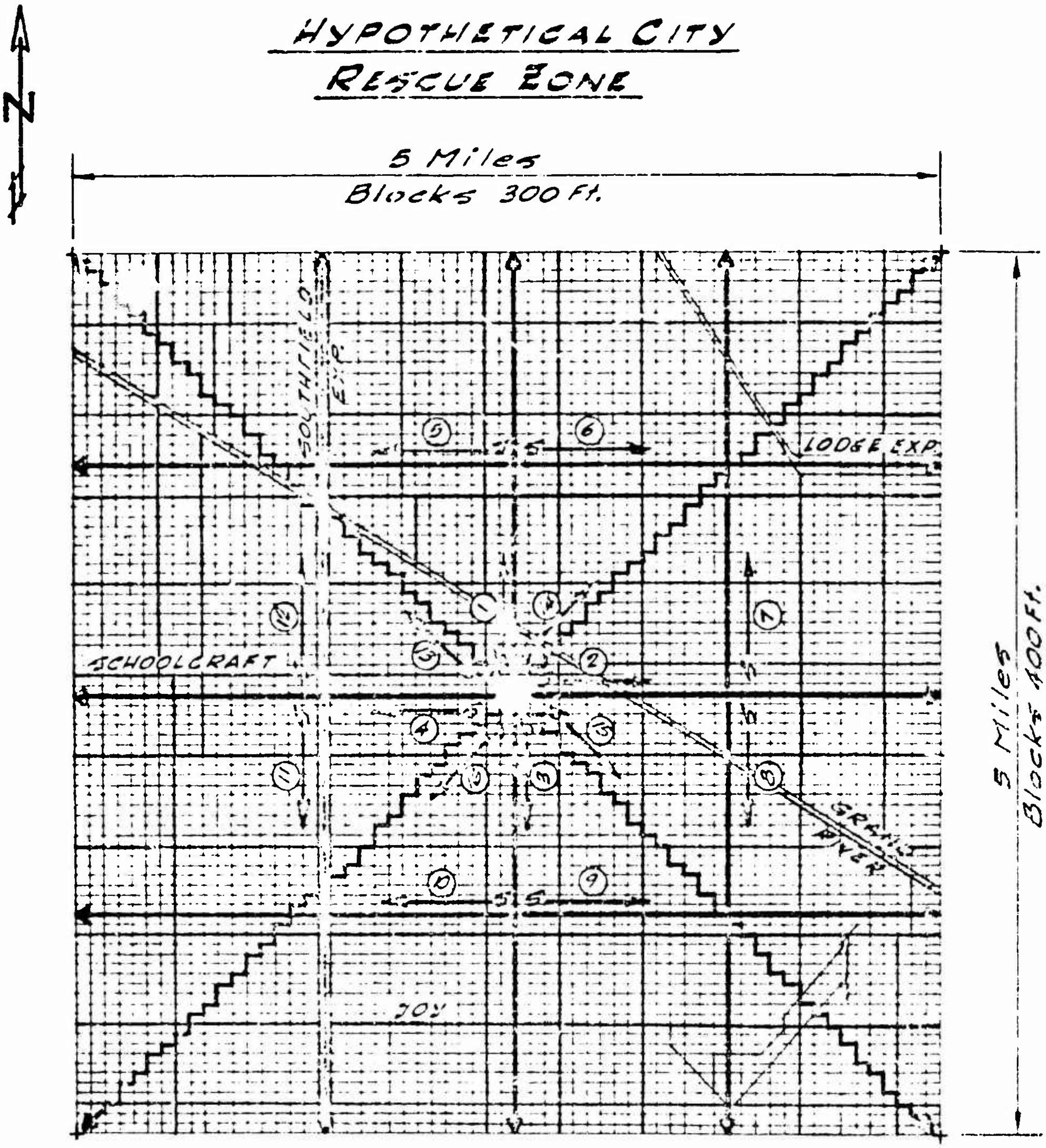
The size in "A" in the above list shows 5 miles by 5 miles which is for guidance only as zone size and shape will depend on local situations.

Building types in "B" of the list indicates the predominant material of construction and building size. This, for example, might be "wood" or "masonry" etc., and would also specify "one (or two) story" or "multi-story" construction.

Building use in "C" of the list is "Residential", "Commercial", or "Industrial", usually designated in these studies as "R", "C", or "I" respectively.

The command post, in each zone, for many city emergency plans is called the Multi-purpose Staging Area or MSA and will be called MSA in this discussion. The manager of the overall emergency recovery operation for the zone, including activities other than debris, will also be located at the MSA. The director of the debris removal function will report to this

HYPOTHETICAL CITY
RESCUE ZONE



NOTES:

1 - ✱ - MSA

2 - Short arrows with "5" gives start and direction of route.

3 - Numbers in circles with short arrows are route numbers.

4 - Heavy lines are general location of routes.

5 - Arrows on route show end of route.

FIGURE A-1

General Zone Manager but may also have contact with the debris manager for the city or metropolitan area or other zones. Equipment interchange may be necessary between zones and direct contact between zone debris groups should be encouraged and reported later to those others in the zone headquarters who may be affected. The MSA headquarters will establish zone task priorities and provide the facilities for routine communication with the city headquarters and other zones. The MSA management will give direction on priorities of tasks to the zone's debris group and provide for it consumable supplies such as fuel and lubricants.

Field Survey of Debris Potential:

Figure A-2 is a Debris Prediction Survey (DPS) form which is the basic document used to predict debris characteristics and quantities. These forms can be used singly for a complete zone, but in some cases a 5 mile by 5 mile (or 25 square mile) zone should be divided into several smaller subzones for DPS analysis. This further division of zones may be needed to assure that the DPS sheet is restricted to similar conditions, of building construction, use or density. It is unlikely that the same conditions of building construction or use or other factors such as building density will repeat themselves throughout many five mile by five mile zones in any city. These DPS forms normally are filled in partially by a drive through survey of the zone during pre-event planning but some of the entries may be done in part by study of city maps or of special maps such as those used for insurance analyses.

________ - ZONE NO. ________

(A) Block Size________ (B) Street Width________ (C) Building Coverage________ (D) Ave. Bldg. Height________

(E) Building Type________ (F) Building Use________ (G) Trees - Poles________

(H) Comments________

(I) E.B.S.________ (J) Contained Vol.________ (K) Material Factor: Blast________; Blast and Fire________

(L) Potential Debris Material: Blast________; Blast and Fire________ (M) Ave. Depth Factor________ (N) D ÷ B________

PREDICTED ENVIRONMENTS

ATTACK CONDITION	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Incident Over-Pressure PSI	Damage Light-L Moderate-M Severe-S	Off Site Factor	Vol. Off Site Debris Cu.Ft./Lin.Ft	Average Depth Feet	Ratio Maximum To Average Depth	DEBRIS DESCRIPTION				PREDICTED DEBRIS TYPE
							Maximum Depth	Maximum Size	CONTENTS		
									Building	Trees Etc.	
BLAST ONLY											
BLAST AND FIRE											

FIGURE A-2

The DPS form is identified by an assigned zone or sub-zone number; and then it is completed as follows:

A - Fill in the average "Block Size" in length and width in feet by drive through observation or from maps, or both.

B - "Street Width" is inserted on the form and is the surveying engineer's estimate of the average width of streets, judged usually from the drive through observation but checked by maps which may be available.

C - "Building Coverage" is the percentage of land, other than that in streets, that is covered by buildings. This in most cases will be a judgment entry based on the drive through or map study.

D- The average "Building Height" is the average of the heights of all buildings in the zone. This again, is an estimate or a judgment of the average height.

E - The "Building Type" is determined from Table A.1, for appropriate building description and code number.

F - "Building Use" is for the predominant use of the buildings in the zone, or sub-zone. The building use is either "C" for commercial, "I" for industrial or "R" for residential.

G - "Trees and poles" is a relative decision such as "none", "moderate" or "heavy".

H - "Comments" is for any unusual situations which might affect

TYPES OF BUILDINGS

Type No.	Description
1	Wood Frame
2	Unreinforced Masonry Load - Bearing Wall
3	Light Steel Frame Industrial - Corrugated Asbestos Sheathing
4	Light Steel Frame Industrial - Corrugated Metal Sheathing
5	Medium Steel Frame Industrial - Corrugated Asbestos Sheathing
6	Medium Steel Frame Industrial - Corrugated Metal Sheathing
7	Heavy Steel Frame Industrial - Corrugated Asbestos Sheathing
8	Heavy Steel Frame Industrial - Corrugated Metal Sheathing
9	Multistory Heavy Reinforced Concrete Shearwall - Light Interior Panels
10	Multistory Heavy Reinforced Concrete Shearwall - Masonry Interior Panels
11	Multistory Reinforced Concrete Shearwall - Light Interior Panels
12	Multistory Reinforced Concrete Shearwall - Masonry Interior Panels
13	Multistory Steel or Reinforced Concrete Frame - Light Exterior Panels - Non Earthquake
14	Multistory Steel or Reinforced Concrete Frame - Masonry Exterior Panels - Non Earthquake
15	Multistory Steel or Reinforced Concrete Frame - Light Exterior Panels - Earthquake
16	Light Reinforced Concrete Frame - Masonry Exterior Panels - Earthquake
17	Light Reinforced Concrete Shearwall - Concrete Roof - Light Interior Panels
18	Light Reinforced Concrete Shearwall - Concrete Roof - Masonry Interior Panels
19	Light Reinforced Concrete Shearwall - Mill Type Roof - Light Interior Panels
20	Light Reinforced Concrete Shearwall - Mill Type Roof - Masonry Interior Panels

TABLE A.1

the character or quantity of debris or indicate potentially unusual rescue requirements. For example, expected unusual traffic concentrations at different time of day might be noted. It may be noted also that there is an adjacent river or lake which would affect access or movement of resources.

I - The "E.B.S." is the equivalent building strip, found on Table A.2 using "Building Coverage" and "Size or Block" from the survey for control or reference.

J - The "Contained Volume" entry is determined by multiplying "EBS" by the average "Building Height". (See "D").

K - The "Material Factor" is used to determine potential debris generated by different types and uses of buildings affected by both conditions of "blasts only" or by "blast and fire". The factor for each of those conditions is read from Table A.3.

L - The "Potential Debris" for the "Blast Only" condition and for the "Blast and Fire" conditions are determined by multiplying the appropriate "Material Factor" (K) by the "Contained Volume" (J).

M - The "Average Depth Factor" is selected from Table A.4.

N - "D ÷ B" is determined by dividing the "Building Height" (D) by "Street Width" (B) from this survey.

EQUIVALENT BUILDING STRIP
(E.B.S.)

	SIZE OF BLOCK -- FEET					
% of Bldg. Coverage	300 by 100	200 by 200	300 by 200	300 by 300	300 by 400	400 by 400
10	4	5	6	8	9	11
20	8	11	13	16	18	21
30	12	16	20	25	28	33
40	16	23	27	34	39	45
50	21	30	35	44	50	59
60	26	37	44	55	63	73
70	30	46	54	68	77	90
80	37	56	65	84	94	110
90	43	68	79	103	115	136
100	50	100	100	150	150	200

$$\text{E.B.S.} = \frac{(L \times W)^{1/2} - [LW(1-C)]^{1/2}}{2}$$

Where L = Length of Block, Ft.

W = Width of Block, Ft.

C = Percentage of block covered by buildings (Expressed as a decimal)

TABLE A.2

DEBRIS FACTORS

BUILDING VOLUME x FACTOR GIVES POTENTIAL DEBRIS VOLUME

Building Type	BLAST ONLY			BLAST & FIRE		
	Res.	Com.	Ind.	Res.	Com.	Ind.
1	.218	.354		.026	.076	
2	.378	.494	.390	.186	.230	.216
3	-	.164	.188	-	.040	.052
4	-	.158	.182	-	.034	.046
5	-	.162	.188	-	.040	.052
6	-	.160	.184	-	.036	.048
7	-	.166	.190	-	.042	.054
8	-	.160	.184	-	.036	.048
9	-	.380	.456	-	.216	.242
10	-	.460	.536	-	.296	.322
11	.276	.406	.290	.132	.180	.162
12	.376	.506	.390	.230	.278	.260
13	.256	.392	.138	.116	.164	.146
14	.330	.466	.350	.190	.238	.220
15	.270	.406	.290	.130	.178	.160
16	.350	.486	.370	.208	.256	.238
17	.280	.340	.320	.134	.168	.172
18	.290	.350	.330	.148	.182	.186
19	-	.274	.254	-	.102	.106
20	-	.300	.280	-	.132	.136

Note: Res = Residential; Com. = Commercial; Ind. = Industrial

TABLE A.3

AVERAGE DEPTH FACTOR

Width of Street Ft.	SIZE OF BLOCK - FEET 300 by 100	200 by 200	300 by 200	300 by 300	300 by 400	400 by 400
30	.026	.020	.023	.021	.023	.021
40	.019	.015	.017	.015	.017	.016
50	.015	.011	.013	.012	.013	.012
60	.012	.009	.011	.010	.011	.010
70	.010	.008	.009	.008	.009	.009
80	.009	.007	.008	.007	.008	.007
90	.008	.006	.007	.006	.007	.006
100	.007	.005	.006	.005	.006	.006
110	.006	.004	.005	.005	.006	.005
120	.005	.004	.005	.004	.005	.005

TABLE A.4

This completes the field survey of debris potential. The actual quantities and characteristics of the debris can be computed in the office.

Computation of Debris

After the top part of the DPS sheet has been completed in the field, details of debris expected are computed and inserted on the lower part of the form using procedures described below.

It is suggested that overpressures (psi) of 2, 4, 6 and 10 be listed in the pre-event analysis. There is not enough difference in effect of 6 or 8 psi to use both. In most cases an overpressure of 10 psi or more will have caused so much damage that rescue efforts in short periods of time will be ineffective. Similarly at more than 10 psi, destruction and distribution of debris in the streets will be very similar to that at 10 and so complete that not much can be done in the three hour time frame of this study, except in situations of very low density of buildings.

The columns in the lower part of the DPS sheet, can be filled in as follows:

1- "Incident Overpressure" is entered in the first column of the "Blast Only" section as 2, 4, 6 and 10, as suggested and discussed above. This should be repeated for the blast and fire section.

2 - "Damage" is a judgment entry and is designated by a letter, of (L) light (M) medium and (S) severe. Gen-

erally, overpressures of 4 psi or lower will be light, 4 to 6 psi will be moderate and over 6 psi severe. This arbitrary scale might be reduced about one level for sparsely settled areas and similarly raised for densely built up sections, for example for high rise buildings on narrow streets.

3 - The "Off Site Factor" is selected from Table A.5 for the appropriate pressure and the building type.

4 - Volume of "Off Site Debris" is the "Off Site Factor" (3) multiplied by the "Potential Debris", the "L" entry in the top part of the DPS form.

5 - The average depth is the volume of off site debris from column (4) times the average depth factor from "M" at the top of the form.

6 - The ratio of maximum to average depth possibilities column (6) will serve as a guide in equipment assignment and will be selected from Table A.6.

7 - The maximum depth in column (7) is the average depth (5) times the ratio of maximum to average depth from column (6).

8 - The maximum size in inches in column (8) is selected from the "S" column on Table A.7 using building type as shown in "E", building use from "F" and forecasts

OFF SITE DEBRIS FACTOR

Bldg. Type	Overpressure psi 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	.034	.274	.500	.600										
2	0	0	0	.007	.050	.180	.5[illegible]0	.600							
3	.200	.500	.60												
4	.055	.220	.30												
5	.170	.40	.60												
6	.025	.10	.15												
7	.081	.30	.40												
8	.025	.10	.15												
9	.002	.006	.010	.027	.033	.043	.067	.080	.112	.130	.150	.170	.190	.200	.220
10	0	0	.005	.017	.042	.072	.116	.163	.218	.289	.361	.400	.450	.500	.500
11	0	.003	.008	.017	.028	.043	.060	.081	.112	.141	.150	.160	.170	.180	.190
12	0	0	.006	.025	.053	.096	.144	.217	.280	.361	.400	.450	.500	.500	
13	0	.006	.018	.041	.072	.105	.162	.200	.225	.250	.300				
14	0	0	.019	.073	.106	.165	.443	.550	.600	.600					
15	0	.002	.009	.025	.045	.072	.105	.145	.200	.250	.300	.300			
16	0	0	.010	.040	.095	.174	.296	.402	.550	.600	.600				
17	0	.001	.006	.012	.012	.050	.228	.510	.550	.600	.600				
18	0	0	.018	.072	.154	.230	.420	.648	[illegible]	.800					
19	0	.033	.132	.300	.350	400	.400								
20	0	.006	.101	.289	.580	.650	.650								

TABLE A.5

RATIO OF MAXIMUM DEPTH TO AVERAGE DEPTH

Bldg. Ht.-St. Width D/B-Input (N)	Incident Overpressure								
	2	3	4	5	6	7	8	9	10
.2	12:1	10:1	6:1	6:1	5:1	4:1	3:1	2:1	1:1
.4	12:1	10:1	6:1	5:1	4:1	3:1	2:1	2:1	1:1
.6	10:1	8:1	6:1	5:1	4:1	3:1	2:1	1:1	
.8	8:1	6:1	5:1	4:1	3:1	2:1	1:1		
1.0	8:1	5:1	5:1	4:1	3:1	2:1	1:1		
1.2	6:1	5:1	4:1	3:1	2:1	1:1			
1.4	6:1	4:1	3:1	3:1	2:1	1:1			
1.6	6:1	4:1	3:1	2:1	2:1	1:1			
1.8	5:1	4:1	3:1	2:1	2:1	1:1			
2.0	5:1	4:1	3:1	2:1	2:1	1:1			
2.5	5:1	3:1	3:1	2:1	1:1				
3.0	5:1	3:1	2:1	2:1	1:1				
3.5	4:1	3:1	2:1	2:1	1:1				
4.0	4:1	3:1	2:1	1:1					
4.5	3:1	2:1	2:1	1:1					
5.0	3:1	2:1	1:1						
6.0	3:1	2:1	1:1						
8.0	3:1	2:1	1:1						
10.0	2:1	2:1	1:1						

TABLE A.6

MAX. SIZE DEBRIS

STRUCTURAL CONTENT

Bldg. Type	Light Damage						Moderate Damage						Severe Damage					
	Resid.		Commer.		Indus.		Resid.		Commer.		Indus.		Resid.		Commer.		Indus.	
	S	CC	S	CC	S	CC	S	CC	S	CC	S	CC	S	CC	S	CC	S	CC
1	3	1	6	1	-	-	14	2	20	3	-	-	30	2	30	3	-	-
2	18	1	24	1	24	3	30	1	30	3	24	3	30	1	36	3	36	4
3	-	-	12	3	12	3	-	-	24	3	30	4	-	-	30	3	48	4
4	-	-	12	3	12	3	-	-	24	3	30	4	-	-	40	3	48	4
5	-	-	6	3	18	3	-	-	48	3	60	4	-	-	60	5	72	5
6	-	-	6	3	18	3	-	-	48	3	60	4	-	-	60	5	72	5
7	-	-	6	1	24	3	-	-	48	4	60	4	-	-	72	5	72	5
8	-	-	6	1	24	3	-	-	48	4	60	4	-	-	72	5	72	5
9	-	-	36	3	36	3	-	-	60	4	48	4	-	-	72	5	72	5
10	-	-	24	3	36	3	-	-	60	4	48	4	-	-	72	5	72	5
11	30	3	30	3	36	3	46	4	60	4	72	5	72	5	72	5	72	5
12	30	3	30	3	36	3	48	4	60	4	72	5	72	5	72	5	72	5
13	30	3	36	4	48	4	48	3	60	5	60	5	60	4	72	5	72	5
14	14	3	30	3	36	3	30	3	48	4	48	4	48	5	60	5	60	5
15	14	1	24	3	24	3	30	3	48	4	48	4	30	5	60	5	60	5
16	14	1	30	3	30	3	30	3	48	4	48	4	48	5	60	5	60	5
17	30	3	36	3	36	3	48	3	48	4	48	5	60	4	72	5	72	5
18	30	3	36	3	36	3	48	3	48	4	48	5	60	4	72	5	72	5
19	-	-	24	3	36	3	-	-	36	3	48	3	-	-	60	5	60	5
20	-	-	24	3	36	3	-	-	36	3	48	3	-	-	60	5	60	5

Abbreviations: S = Size in inches; CC = Content Code

TABLE A.7

of damage levels of light, moderate or severe, which have already been inserted in Column 2 on the DPS sheet.

9 - The building contents code for column (9) can be found in the appropriate "CC" column in Table A.7.

10 - Trees and poles condition of "light", "medium", or "heavy" is repeated from the top of the form "G".

11 - The debris type is called parameter A and is selected by judgment from Table A.8 as that one most closely fitting the combination of debris conditions of maximum size, range of depths and estimated structural content for the building type shown as "E".

It should be noted that all of this should be completed prior to the emergency. The debris manager having access to this information will have a reasonably accurate picture of what to anticipate in the way of debris removal problems under various conditions before the actual event. His main concern immediately following the explosion will be in establishing priority of tasks and matching available resources to those tasks.

RESOURCE EVALUATION

The two principal resources most critical to debris removal, and which are more or less independent of the resource needs of other emergency actions, are construction equipment and construction personnel. Other activities will use larger quantities of most of the other supplies

DEBRIS DESIGNATIONS

Debris Designation	Range of Max. Size Inches	Range of Max. Depth Feet	Structural Content
1-1	1-6	0.1-1	None
1-2	1-6	0.1-1	Wood
2-3	7-14	1.1-3	Light Steel
3-1	15-30	3.1-6	None
3-2	15-30	3.1-6	Wood
3-3	15-30	3.1-6	Light Steel
3-4	15-30	3.1-6	Medium Steel
3-5	15-30	3.1-6	Heavy Steel
4-3	31-48	6.1-10	Light Steel
4-4	31-48	6.1-10	Medium Steel
4-5	31-48	6.1-10	Heavy Steel
5-3	49-60	10.1-15	Light Steel
5-4	49-60	10.1-15	Medium Steel
5-5	49-60	10.1-15	Heavy Steel
6-4	61-72	15.1-20	Medium Steel
6-5	61-72	15.1-20	Heavy Steel

TABLE A. 8

which are also required and critical in debris removal such as fuel and lubricants. It is assumed, therefore, that provision and control of these shared resources will be the responsibility of others in the emergency headquarters. The zone debris removal manager will draw on those MSA controlled supplies through channels established, and with procedures defined, by the headquarters.

The main equipment for the emergency periods will be bulldozers, front end loaders, and motor graders. These are most likely to be found in the yards of dealers, and local contractors, particularly those contractors who do road and building excavation work in the immediate area. They should be inventoried in the pre-event period and the inventory kept current by the city or area office concerned with emergency preparedness planning.

In many cases there will be one or more organizations of contractors locally and these associations traditionally will cooperate fully with planning such operations for the public good by providing critical equipment inventory data or assistance in gathering it.

An equipment inventory record as shown by Figure A-3 will be filled out for each contractor or owner by the overall city or area debris planner in the pre-event time period. He will use these sheets to make his overall inventory from which he will allocate equipment to the zones. This type of form in Figure A.3 is self-explanatory giving the name and location of the contractor's yard. Each yard when first inventoried will be assigned a serial number. If the contractor has more than one perm-

EQUIPMENT INVENTORY - LOCATOR

SOURCE OR FIRM ____________________ LOCATION SERIAL NO. __________

STREET (OFFICE) ____________________ CITY ____________________

PHONE ____________________ RADIO FREQUENCY ____________________

STREET (STORAGE YARD) ____________________ CITY. ____________________

PHONE ____________________ CONTACT(S) ____________________

Equipment	Type	H.P. Or Cap.		Code	Manufacturer	Model	Con-dition	No
		Value	Unit					

FIGURE A-3

anent yard, a record should be made for each yard, but not for casual or temporary locations that he has established to service a single job even though such a job may last a year or two.

The inventory will list under the "Equipment" column the name "Bulldozer", "Shovel" etc. In the "type" column is "crawler" or "wheel". The approximate horsepower or capacity rating of the equipment is shown in the "Value" column under "Horsepower" or "Capacity" and the "Unit" column merely indicates whether the value is expressed in horsepower or bucket capacity in cubic yards.

The code for the equipment is inserted after being selected from the third column of Table A.9. The manufacturer and model designation are entered on the inventory in the appropriate columns. Anything unusual about the condition of the equipment will be shown, but if it is in good order and ready for normal duty, as it may normally be expected to be, the "condition" column will be blank. The quantity of that type of unit in the yard is shown in the last column.

A summary of the units available in the area will be listed by code number on a form like Figure A-4 which is an overall inventory. Depending on the local situation, this inventory summary may be further divided into general areas of the metropolitan area, as perhaps "South", "North", "Central," etc., or even into the emergency zones. This additional breakdown would be only for convenience and more orderly assignments and should not become so complex as to be burdensome.

CRITICAL SURVIVAL PATH

EQUIPMENT CODE AND CAPACITY

Type		Code	Maximum Hp.	Minimum Rte. Width	Optimum cu.yd/hr.	Adjusted cu.yd/hr.		
						Space Adj.	Prod. Factor *	
							0.72	0.53
Bulldozer	Crawler	280	150	12	140	125	90	65
		282	200	12	230	210	150	110
		284	250	14	330	300	215	160
		286	300	16	400	360	260	190
		288	300	16	520	470	340	250
	Wheeled	283	200	12	190	170	120	90
		285	250	12	275	250	180	130
		287	300	14	350	320	230	170
		289	300	16	530	480	350	260
Front End Loader	Crawler	160	150	10	100	90	65	50
		162	200	10	140	125	90	65
		164	250	12	185	165	120	90
		166	300	14	245	220	160	115
	Wheeled	161	150	10	130	115	85	60
		163	200	10	185	165	120	90
		165	250	12	250	225	160	120
		167	300	12	330	300	215	160
		169	300	14	430	390	280	210
Motor Grader		141	150	14	160	145	105	75
		143	200	16	200	180	130	95
		145	250	16	280	250	180	130

* Note: Productivity Factor 0.72 used for debris type 2-3, 3-2 & 3-3
0.53 used for debris type 4-3

TABLE A.9

KEY EQUIPMENT INVENTORY

SUMMARY

CITY____________________ DATE__________

QUANTITY

Owner Serial No.	EQUIPMENT CODE											

FIGURE A-4

Personnel resources can be established by contacting the following agencies:

A. The management and clerical talent needed can be provided by contacting the most active organization of contractors in the area. This association may be the Association of General Contractor's (AGC), but in some cities other associations may be closer to the intermediate or smaller local contractors, who will be most useful in this work. Frequently, the larger international contractors have little equipment or job managers at the home base, although a few have kept operative a group for local activity.

B. Operators, helpers and mechanics can be requested from the local union hiring hall. Contact in the planning phase should be established with all offices in the immediate area, in the event any one or more of the union offices may be disabled by the event. Some of the equipment will be accompanied by an operator on its arrival at the staging area as frequently such operators are more or less permanently assigned to a unit by an owner.

Studies to date indicate that there will be adequate personnel available for the emergency clearing tasks. In addition to local sources such personnel could be available for an emergency from other areas within one or two hours transport time to most cities.

The city debris removal manager will make an analysis of the general city-wide situation taking into account the physical features of the zones and of the overall equipment inventory. A pre-event allocation of equipment should be made, based on this judgment. Generally, it is expected that a 5 x 5 mile zone will require 10 to 20 tractors or front end loaders depending on the concentration of buildings in the area. About two motor graders should be assigned to each zone for rapid light "street sweeping" assignments.

Mobilization action should be established to be taken in the case of a pre-event warning. Such a warning may be possible for such events as nuclear attacks or hurricanes. The overall city or area debris manager in such a case may be directed to mobilize in anticipation of an event. He should man each MSA with a zone debris manager who may be from the city staff but more than likely will have been furnished by the local contractor's association as most of the qualified city personnel will have other assignments related to recovery.

At the time of mobilization, the zone debris manager will move into the MSA and establish communication with overall zone manager. He will then establish a small office force of perhaps two or three to maintain records, provide communication and perform office management tasks.

This staff might also be provided by the contractors as it would be desirable to have people familiar with excavation terminology and methods. The size of the administrative group will depend on the local situation.

The debris manager for the zone will contact owners of the equipment which has been allocated to him and, if it has not been done, start movement to the MSA of all or part of the allocation as may have been determined as essential for the initial requirements. The equipment will be fully fueled and serviced so as to be prepared for at least one eight hour shift operation without interruption.

At this point, the zone debris manager will know how much and what types of operating personnel he must obtain from the union hiring hall. He will contact the local union and have that personnel sent to the MSA.

Quarters will be provided for the operators and staff during the emergency period and communication established between the command post and these quarters preferably by radio as well as phone if the MSA and quarters are physically separated. It is envisioned that the MSA may be a school or shopping center and the quarters may be a nearby motel.

IMPLEMENTATION

The zone debris manager in the planning stage of advanced warning will receive instructions from the zone manager on probable routes to be cleared and their priority. It is assumed that there will be some warning and that the advance mobilization will allow the zone debris manager to make a provisional evaluation of the situation. If provisional tasks have not been specified by higher command, the zone debris manager should indicate several routes on the map Figure A-1 to serve this purpose. These tasks are numbered and can be described on a task evaluation sheet shown as Figure A-5.

The completed DPS sheet on Figure A-2 provides most of the data required for the top part of Figure A-5 for task evaluation. The exception to this is data in the table for volumes of debris per 1000 lineal feet for each of 4 route widths. These are obtained as follows:

Debris/1000 lineal feet = $(DW + D^2)$

Where $D = d \times M$

d = Average depth from DPS

M = Meandering factor from Table A.10

w = Route width in feet as shown in column (4)

The real, or assumed route numbers, are put in the first column on the lower part. Next equipment is assigned in column (3), by code, and from the equipment assignment sheet, Figure A-6. Equipment will be chosen from that equipment listed as assigned to the zone which list may simply show the equipment code and its originating yard's serial number.

The route width for column (4) is found on Table A.9 for that piece of equipment and, using that and the table at the top of the task evaluation form, the debris in cubic yards per 1000 feet can be entered in column (2).

The standard production for column (5) is selected from Table A.9 as is the adjusted production for columns (6) and (7). The standard

TASK EVALUATION SHEET - DEBRIS

Zone No. ____________ Ov. Pr. PSI ___________ % Cov. Bldgs. ____________

General Description: ____

Building: Type ________________ Height ___________ Use ____________

Debris Type ____________

Street Width ____________

Rt. Width	10	12	14	16
Deb/1000 ft.				

				Equip. Cap. - Cu. Yds.				Lin. Ft./3 Hrs.	
Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Per Unit	Cumul. All Units

FIGURE A-5

FACTORS FOR OVERALL
AVERAGE DEBRIS DEPTH TO MEANDERING
ROUTE AVERAGE DEPTH

BLDG. HT/STR. WIDTH D/B - INPUT (N)	INCIDENT OVERPRESSURE								
	2	3	4	5	6	7	8	9	10
0.2	.15	.15	.20	.20	.25	.30	.40	.60	1.0
0.4	.15	.15	.20	.25	.30	.40	.60	.60	1.0
0.6	.15	.20	.20	.25	.30	.40	.60	1.0	
0.8	.20	.20	.25	.30	.40	.60	1.0		
1.0	.20	.25	.25	.30	.40	.60	1.0		
1.2	.20	.25	.30	.40	.60	1.0			
1.4	.20	.30	.40	.40	.60	1.0			
1.6	.20	.30	.40	.60	.60	1.0			
1.8	.25	.30	.40	.60	.60	1.0			
2.0	.25	.30	.40	.60	.60	1.0			
2.5	.25	.40	.40	.60	1.0				
3.0	.25	.40	.60	.60	1.0				
3.5	.30	.40	.60	.60	1.0				
4.0	.30	.40	.60	1.0					
4.5	.40	.60	.60	1.0					
5.0	.40	.60	1.0						
6.0	.40	.60	1.0						
8.0	.40	.60	1.0						
10.0	.60	.60	1.0						

TABLE A.10

EQUIPMENT ASSIGNMENT SHEET

Zone Equipment-City ____________________ Zone ________ Date ____________

Identity	Code	Owner	Route No.	Point of Origin	Route Along	Route End	Time	
							Out	In

FIGURE A-6

production rates are adjusted for confined working space and debris conditions. The productivity factors used in Table A.9 are for the debris types most prevalent in the hypothetic. . situations of this report.

The net production in 3 hours for column (8) is simply three times the hourly rate in column (7). Dividing the production capacity in column (8) by the debris volume per 1000 ft. in column (2) gives the distance cleared in three hours for column (9). Some routes will have more than one piece of equipment assigned. The 10th and last column is cumulative distance cleared for all equipment units assigned to a route.

A summary of the total feet cleared for each of the routes in the last column will give a preliminary evaluation of the debris clearing potential.

Preliminary task assignments, pending instructions from zone headquarters, may be made following the above guideline so that debris removal can start as so-- after an event as crews and machinery can be mobilized. T' :s, considerable debris may be removed while the zone headquarters is collecting intelligence data as to where it may be critical to clear emergency paths.

The preliminary routes will probably fan out from the MSA. Certain obvious targets for routes such as hospitals, schools or connecting routes to adjacent zones may be recognized in the preliminary route assignments. The equipment will not have advanced so far that pulling it back for redirection, as a result of post-event intelligence, or other orders from headquarters would cause any difficulty or delay.

In this type of emergency path clearing, no complicated procedures need be established for support equipment. Excavating units normally will be working alone. Occasionally such things as light plants, paving breakers and compressors or water pumps may be needed. These will be the exception and the normal procedure should not be confused or made more complicated to provide them automatically. This can be done as needed by the zone's debris staff.

Orders to equipment operators will be verbal. A record will be kept by the administrative staff of work assignments, hours worked and supplies used. This record should contain: name of operator and equipment; identity by model and serial number, and owner's serial number. A form for this has been prepared as Figure A-6. The "identity" column is for a number to be assigned to each piece of equipment by the zone on receipt of the equipment. A separate record should list the assigned equipment number, the equipment model, make, manufacturer's serial number and the owner's name and serial number. The equipment identity number can be put on a metal tag on a chain to be attached to the equipment for ease of identification.

The completed forms Figure A-6 for each day will be saved for a permanent record of the zone operation. The route's starting street, or intersection, street or direction of it's progress and street or intersection of its end will be written on a separate note for the equipment operator. This dated note will show time of start and completion and be signed by the operator.

The 5 operational forms Figures A2, A3, A4, A5 and A6 are completed using hypothetical data as an example and are included as Tables A.11 through A.15.

________ - ZONE NO. 2

(A) Block Size 300 x 400 (B) Street Width 80 (C) Building Coverage 20% (D) Ave. Bldg. Height 50

(E) Building Type 1 (F) Building Use Residential (G) Trees - Poles Light

(H) Comments

(I) E.B.S. 18 (J) Contained Vol. 900 (K) Material Factor: Blast .218 ; Blast and Fire .026

(L) Potential Debris Material: Blast 196 ; Blast and Fire 23 (M) Ave. Depth Factor .008 (N) D ÷ B 0.625

PREDICTED ENVIRONMENTS

ATTACK CONDITION	(1) Incident Over-Pressure PSI	(2) Damage Light-L Moderate-M Severe-S	(3) Off Site Factor	(4) Vol. Off Site Debris Cu.Ft./Lin.Ft	(5) Average Depth Feet	(6) Ratio Maximum To Average Depth	(7) DEBRIS DESCRIPTION: Maximum Depth	(8) DEBRIS DESCRIPTION: Maximum Size	(9) DEBRIS DESCRIPTION: CONTENTS: Building	(10) DEBRIS DESCRIPTION: CONTENTS: Trees Etc.	(11) PREDICTED DEBRIS TYPE
BLAST ONLY	2	M	0	0	0	--	0	--	--	--	None
	4	S	.274	54	.43	6:1	2.58	30	2	1	3-2
	6	S	.600	118	.94	4:1	3.76	30	2	1	3-2
	10	S	.600	118	.94	1:1	0.94	30	2	1	3-2
BLAST AND FIRE	2	M	0	0	0	--	0	--	--	--	None
	4	S	.274	6	.05	6:1	0.30	30	2	1	1-1
	6	S	.600	14	.11	4:1	0.44	30	2	1	1-1
	10	S	.600	14	.11	1:1	0.11	30	2	1	1-1

TABLE A.11

EQUIPMENT INVENTORY - LOCATOR

SOURCE OR FIRM Jones Paving Company LOCATION SERIAL NO. 101

STREET (OFFICE) 250 Poplar Street CITY Hypothetical, CA 94111

PHONE 415-434-1822 RADIO FREQUENCY None

STREET (STORAGE YARD) Same as above CITY. Same as above

PHONE Same CONTACT(S) Mr. Robt. E. Jones

Equipment	Type	H.P. Or Cap. Value	H.P. Or Cap. Unit	Code	Manufacturer	Model	Condition	No
Bulldozer	Crawler	270	HP	286	Caterpillar	D8		1
"	"	120	HP	280	"	D6		1
Shovels	"	2.5	Cu.Yd.	264	Northwest	80D		2
*F.E. Loaders	"	177	HP	162	Caterpillar	977		2
" "	"	115	"	160	"	955		1
" "	Wheel	150	"	163	"	966		1
" "	"	192	"	163	Wabco	350		2
" "	"	208	"	165	"	400		3
Motorgrader	"	115	"	141	Caterpillar	12		1

* F.E. is "Front End"

TABLE A.12

KEY EQUIPMENT INVENTORY

SUMMARY

CITY Hypothetical Zone - Southside DATE 3/20/73

QUANTITY

Owner Serial No.	EQUIPMENT CODE											
	141	161	162	163	165	167	169	264	280	284	286	288
101	1	2	2	1	0	0	1	0	2	0	3	1
114	2	1	3	3	0	0	0	0	0	1	2	0
116	0	3	0	1	1	1	0	1	1	0	0	0
117	1	0	1	0	2	1	0	0	1	0	1	1
120	3	1	0	0	1	0	0	0	3	0	1	0
	7	7	6	5	4	2	1	1	7	1	7	2

TABLE A.13

TASK EVALUATION SHEET - DEBRIS

Zone No. 2 Ov. Pr. PSI 4 % Cov. Bldgs. 20

General Description: 2-Story frame sngl. family residence on city lots.

Building: Type 1 Height 50 Use RES

Debris Type 3 - 2

Street Width 80

Rt. Width	10	12	14	16
Deb/1000 ft.	34	40	47	54

Route No.	Deb. Cu. Yd. Per 1000 Ft.	Equip. Assigned	Width of Route Ft.	Equip. Cap. - Cu. Yds.				Lin. Ft./3 Hrs. (1000 ft.)	
				Stand Per Hr.	Adj. Space	Adj. Debris	Net 3 Hrs.	Per Unit	Cumul. All Units
1	34 34	160 163	10 10	100 185	90 165	65 120	195 360	5.7 10.6	5.7 16.3
2	34 34	161 162	10 10	130 140	115 125	85 90	255 270	7.5 7.9	7.5 15.4
3	34 40	163 280	10 12	185 140	165 125	120 90	360 270	10.6 6.8	10.6 17.4
4	40 40	165 280	12 12	250 140	225 125	160 90	480 270	12.0 6.8	12.0 18.8
5	34 34	162 162	10 10	140 140	125 125	90 90	270 270	7.9 7.9	7.9 15.8
6	40	167	12	330	300	215	645	16.1	16.1
7	47	284	14	330	300	215	645	13.7	13.7
8	47	284	14	330	300	215	645	13.7	13.7
9	54	286	16	400	360	260	780	14.4	14.4
10	54	286	16	400	360	260	780	14.4	14.4
11	54	288	16	520	470	340	1020	18.9	18.9
								Total	174.9

TABLE A. 14

EQUIPMENT ASSIGNMENT SHEET

Zone Equipment-City Hypothetical Zone 2 Date August 31, 1973

Identity	Code	Owner	Route No.	Point of Origin	Route Along	Route End	Time Out	Time In
84 83	160 163	14 14	1	Kiebler	Greenfield	Grove	0830	1120 1100
12 6	161 162	3 2	2	Greenfield	Kiebler	Livernois	0836	1114 1045
85 14	163 280	14 3	3	Kiebler	Greenfield	Warren	0842	1120 1058
98 86	165 280	4 14	4	Greenfield	Kiebler	Evergreen	0845	1110 1100
16 99	162 162	3 4	5	Greenfield	Ferrell	Evergreen	0850	1130 1105
110	167	10	6	Greenfield	Ferrell	Livernois	0847	1140
60	284	8	7	Kiebler	Schaefer	Grove	0901	1115
61	284	8	8	Kiebler	Schaefer	Warren	0905	1052
62	286	8	9	Greenfield	Plymouth	Livernois	0902	1103
63	286	8	10	Greenfield	Plymouth	Evergreen	0910	1142
13	288	3	11	Kiebler	Southfield	Warren	0915	1145

TABLE A.15

APPENDIX B

REFERENCE TABLES

EQUIVALENT BUILDING STRIP
(E.B.S.)

% of Bldg. Coverage	SIZE OF BLOCK -- FEET					
	300 by 100	200 by 200	300 by 200	300 by 300	300 by 400	400 by 400
10	4	5	6	8	9	11
20	8	11	13	16	18	21
30	12	16	20	25	28	33
40	16	23	27	34	39	45
50	21	30	35	44	50	59
60	26	37	44	55	63	73
70	30	46	54	68	77	90
80	37	56	65	84	94	110
90	43	68	79	103	115	136
100	50	100	100	150	150	200

$$\text{E.B.S.} = \frac{(L \times W)^{1/2} - [LW(1-C)]^{1/2}}{2}$$

Where L = Length of Block, Ft.

W = Width of Block, Ft.

C = Percentage of block covered by buildings (Expressed as a decimal)

TABLE B.1

DEBRIS FACTORS

BUILDING VOLUME x FACTOR GIVES POTENTIAL DEBRIS VOLUME

Building Type	BLAST ONLY			BLAST & FIRE		
	Res.	Com.	Ind.	Res.	Com.	Ind.
1	.218	.354		.026	.076	
2	.378	.494	.390	.186	.230	.216
3	-	.164	.188	-	.040	.052
4	-	.158	.182	-	.034	.046
5	-	.162	.188	-	.040	.052
6	-	.160	.184	-	.036	.048
7	-	.166	.190	-	.042	.054
8	-	.160	.184	-	.036	.048
9	-	.380	.456	-	.216	.242
10	-	.460	.536	-	.296	.322
11	.276	.406	.290	.132	.180	.162
12	.376	.506	.390	.230	.278	.260
13	.256	.392	.138	.116	.164	.146
14	.330	.466	.350	.190	.238	.220
15	.270	.406	.290	.130	.178	.160
16	.350	.486	.370	.208	.256	.238
17	.280	.340	.320	.134	.168	.172
18	.290	.350	.330	.148	.182	.186
19	-	.274	.254	-	.102	.106
20	-	.300	.280	-	.132	.136

Note: Res. = Residential; Com. = Commercial; Ind. = Industrial

TABLE B.2

<u>OFF SITE DEBRIS FACTOR</u>

Bldg. Type	Overpressure psi 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	.034	.274	.500	.600										
2	0	0	0	.007	.050	.180	.540	.600							
3	.200	.500	.60												
4	.055	.220	.30												
5	.170	.40	.60												
6	.025	.10	.15												
7	.081	.30	.40												
8	.025	.10	.15												
9	.002	.006	.010	.027	.033	.043	.067	.080	.112	.130	.150	.170	.190	.200	.220
10	0	0	.005	.017	.042	.072	.116	.163	.218	.289	.361	.400	.450	.500	.500
11	0	.003	.008	.017	.028	.043	.060	.081	.112	.141	.150	.160	.170	.180	.190
12	0	0	.006	.025	.053	.096	.144	.217	.280	.361	.400	.450	.500	.500	
13	0	.006	.018	.041	.072	.105	.162	.200	.225	.250	.300				
14	0	0	.019	.073	.106	.165	.443	.550	.600	.600					
15	0	.002	.009	.025	.045	.072	.105	.145	.200	.250	.300	.300			
16	0	0	.010	.040	.095	.174	.296	.402	.550	.600	.600				
17	0	.001	.006	.012	.012	.050	.228	.510	.550	.600	.600				
18	0	0	.018	.072	.154	.230	.420	.648	.800	.800					
19	0	.033	.132	.300	.350	.400	.400								
20	0	.006	.101	.289	.580	.650	.650								

TABLE B.3

AVERAGE DEPTH FACTOR

Width of Street Ft.	SIZE OF BLOCK - FEET 300 by 100	200 by 200	300 by 200	300 by 300	300 by 400	400 by 400
30	.026	.020	.023	.021	.023	.021
40	.019	.015	.017	.015	.017	.016
50	.015	.011	.013	.012	.013	.012
60	.012	.009	.011	.010	.011	.010
70	.010	.008	.009	.008	.009	.009
80	.009	.007	.008	.007	.008	.007
90	.008	.006	.007	.006	.007	.006
100	.007	.005	.006	.005	.006	.006
110	.006	.004	.005	.005	.006	.005
120	.005	.004	.005	.004	.005	.005

TABLE B.4

FACTORS FOR OVERALL
AVERAGE DEBRIS DEPTH TO MEANDERING
ROUTE AVERAGE DEPTH

BLDG. HT/STR. WIDTH D/B - INPUT (N)	INCIDENT OVERPRESSURE								
	2	3	4	5	6	7	8	9	10
0.2	.15	.15	.20	.20	.25	.30	.40	.60	1.0
0.4	.15	.15	.20	.25	.30	.40	.60	.60	1.0
0.6	.15	.20	.20	.25	.30	.40	.30	1.0	
0.8	.20	.20	.25	.30	.40	.60	1.0		
1.0	.20	.25	.25	.30	.40	.60	1.0		
1.2	.20	.25	.30	.40	.60	1.0			
1.4	.20	.30	.40	.40	.60	1.0			
1.6	.20	.30	.40	.60	.60	1.0			
1.8	.25	.30	.40	.60	.60	1.0			
2.0	.25	.30	.40	.60	.60	1.0			
2.5	.25	.40	.40	.60	1.0				
3.0	.25	.40	.60	.60	1.0				
3.5	.30	.40	.60	.60	1.0				
4.0	.30	.40	.60	1.0					
4.5	.40	.60	.60	1.0					
5.0	.40	.60	1.0						
6.0	.40	.60	1.0						
8.0	.40	.60	1.0						
10.0	.60	.60	1.0						

TABLE B.5

RATIO OF MAXIMUM DEPTH TO AVERAGE DEPTH

Bldg. Ht.-St. Width	Incident Overpressure								
D/B-Input (N)	2	3	4	5	6	7	8	9	10
.2	12:1	10:1	6:1	6:1	5:1	4:1	3:1	2:1	1:1
.4	12:1	10:1	6:1	5:1	4:1	3:1	2:1	2:1	1:1
.6	10:1	8:1	6:1	5:1	4:1	3:1	2:1	1:1	
.8	8:1	6:1	5:1	4:1	3:1	2:1	1:1		
1.0	8:1	5:1	5:1	4:1	3:1	2:1	1:1		
1.2	6:1	5:1	4:1	3:1	2:1	1:1			
1.4	6:1	4:1	3:1	3:1	2:1	1:1			
1.6	6:1	4:1	3:1	2:1	2:1	1:1			
1.8	5:1	4:1	3:1	2:1	2:1	1:1			
2.0	5:1	4:1	3:1	2:1	2:1	1:1			
2.5	5:1	3:1	3:1	2:1	1:1				
3.0	5:1	3:1	2:1	2:1	1:1				
3.5	4:1	3:1	2:1	2:1	1:1				
4.0	4:1	3:1	2:1	1:1					
4.5	3:1	2:1	2:1	1:1					
5.0	3:1	2:1	1:1						
6.0	3:1	2:1	1:1						
8.0	3:1	2:1	1:1						
10.0	2:1	2:1	1:1						

TABLE B.6

MAX. SIZE DEBRIS

STRUCTURAL CONTENT

Bldg. Type	Light Damage						Moderate Damage						Severe Damage					
	Resid.		Commer.		Indus.		Resid.		Commer.		Indus.		Resid.		Commer.		Indus.	
	S	CC	S	CC	S	CC	S	CC	S	CC	S	CC	S	CC	S	CC	S	CC
1	3	1	6	1	-	-	14	2	20	3	-	-	30	2	30	3	-	-
2	18	1	24	1	24	3	30	1	30	3	24	3	30	1	36	3	36	4
3	-	-	12	3	12	3	-	-	24	3	30	4	-	-	30	3	48	4
4	-	-	12	3	12	3	-	-	24	3	30	4	-	-	40	3	48	4
5	-	-	6	3	18	3	-	-	48	3	60	4	-	-	60	5	72	5
6	-	-	6	3	18	3	-	-	48	3	60	4	-	-	60	5	72	5
7	-	-	6	1	24	3	-	-	48	4	60	4	-	-	72	5	72	5
8	-	-	6	1	24	3	-	-	48	4	60	4	-	-	72	5	72	5
9	-	-	36	3	36	3	-	-	60	4	48	4	-	-	72	5	72	5
10	-	-	24	3	36	3	-	-	60	4	48	4	-	-	72	5	72	5
11	30	3	30	3	36	3	48	4	60	4	72	5	72	5	72	5	72	5
12	30	3	30	3	36	3	48	4	60	4	72	5	72	5	72	5	72	5
13	30	3	36	4	48	4	48	3	60	5	60	5	60	4	72	5	72	5
14	14	3	30	3	36	3	30	3	48	4	48	4	48	5	60	5	60	5
15	14	1	24	3	24	3	30	3	48	4	48	4	30	5	60	5	60	5
16	14	1	30	3	30	3	30	3	48	4	48	4	48	5	60	5	60	5
17	30	3	36	3	36	3	48	3	48	4	48	5	60	4	72	5	72	5
18	30	3	36	3	36	3	48	3	48	4	48	5	60	4	72	5	72	5
19	-	-	24	3	36	3	-	-	36	3	48	3	-	-	60	5	60	5
20	-	-	24	3	36	3	-	-	36	3	48	3	-	-	60	5	60	5

Abbreviations: S = Size in inches; CC = Content Code

TABLE B.7

DEBRIS DESIGNATIONS

Debris Designation	Range of Max. Size Inches	Range of Max. Depth Feet	Structural Content
1-1	1-6	0.1-1	None
1-2	1-6	0.1-1	Wood
2-3	7-14	1.1-3	Light Steel
3-1	15-30	3.1-6	None
3-2	15-30	3.1-6	Wood
3-3	15-30	3.1-6	Light Steel
3-4	15-30	3.1-6	Medium Steel
3-5	15-30	3.1-6	Heavy Steel
4-3	31-48	6.1-10	Light Steel
4-4	31-48	6.1-10	Medium Steel
4-5	31-48	6.1-10	Heavy Steel
5-3	49-60	10.1-15	Light Steel
5-4	49-60	10.1-15	Medium Steel
5-5	49-60	10.1-15	Heavy Steel
6-4	61-72	15.1-20	Medium Steel
6-5	61-72	15.1-20	Heavy Steel

TABLE B.8

ADJUSTMENT OF DEBRIS DESIGNATIONS

TRAFFIC CONTENT

Debris Designation	Adjusted Debris Designation		
	Light (1)	Medium (2)	Heavy (3)
1-1	1-1	1-1	2-3
1-2	1-2	2-3	2-3
2-3	3-3	3-3	3-4
3-1	3-3	3-4	3-5
3-2	3-4	3-5	4-3
3-3	3-4	4-3	4-4
3-4	3-5	4-4	4-5
3-5	4-3	4-5	5-3
4-3	4-5	5-3	5-4
4-4	5-3	5-4	5-5
4-5	5-4	5-5	5-5
5-3	5-4	5-5	5-5
5-4	5-5	5-5	6-4
5-5	6-4	6-4	6-5
6-4	6-4	6-5	6-5
6-5	6-5	6-5	6-5

TABLE B. 9

STANDARD PRODUCTION

Major Equipment			Item	Code & Standard Production Cu.Yd./Hr.				
Bulldozer		Crawler	Code	280	282	284	286	288
			Rate	140	230	330	400	520
		Wheel	Code		283	285	287	289
			Rate		190	275	350	530
Front End Loader	End Dump	Crawler	Code	160	162	164	166	
			Rate	100	140	185	245	
		Wheel	Code	161	163	165	167	169
			Rate	130	185	250	330	430
	Side Dump	Crawler	Code	170	172	174	176	
			Rate	125	190	215	290	
		Wheel	Code	171	173	175	177	179
			Rate	155	220	300	400	525
Motor Grader		Wheel	Code	141	143	145		
			Rate	160	200	280		
Shovel		Crawler	Code	260	262	264	266	268
			Rate	80	160	220	260	320
		Wheel	Code	261				
			Rate	80				

TABLE B.10

COMPOSITE ADJUSTMENT FACTORS

Debris Designation	Factors For Varying Traffic Content								
	Bulldozer			Front End Loaders			Shovels		
	1	2	3	1	2	3	1	2	3
1-1	1.00	1.00	.86	.97	.97	.86	.48	.48	.47
1-2	.93	.86	.86	.87	.86	.86	.47	.47	.47
2-3	.75	.75	.72	.72	.72	.71	.43	.43	.42
3-1	.75	.72	.71	.72	.71	.69	.43	.42	.41
3-2	.72	.71	.59	.71	.69	.58	.42	.41	.41
3-3	.72	.59	.57	.71	.58	.53	.42	.41	.40
3-4	.71	.57	.53	.69	.53	.51	.41	.40	.38
3-5	.59	.53	.43	.58	.51	.47	.41	.38	.32
4-3	.53	.43	.40	.51	.47	.45	.38	.32	.29
4-4	.43	.40	.33	.47	.45	.36	.32	.29	.24
4-5	.40	.33	.33	.45	.36	.36	.29	.24	.24
5-3	.40	.33	.33	.45	.36	.36	.29	.24	.24
5-4	.33	.33	.22	.36	.36	.25	.24	.24	.16
5-5	.22	.22	.16	.25	.25	.18	.16	.16	.12
6-4	.22	.16	.16	.25	.18	.18	.16	.12	.12
6-5	.16	.16	.16	.18	.18	.18	.12	.12	.12

NOTE: Traffic Content: Light (1), Medium (2), Heavy (3)

TABLE B.11

MULTIPLE UNITS

COMBINATION FACTORS

Width of Route - Ft.	50 Feet			30 Feet			20 Feet		
No. of Units	1	2	3	1	2	3	1	2	3
Bulldozer	1.0	1.7	2.1	1.0	1.6	2.0	1.0	1.3	
F.E. Loader E.D.	1.0	1.2		1.0	1.2		0.6		
F.E. Loader S.D.	1.0	1.8	2.0	1.0	1.5		0.9	1.2	
Motor Grader	1.0	1.6		1.0	1.6		0.8		
Shovel	1.0	1.2		0.7			0.5		
Clamshell	1.0			0.7					
Backhoe	1.0	1.2		1.0	1.1		0.6		
Scraper	0.8			0.6					

Note: F.E. = Front End
E.D. = End Dump
S.D. = Side Dump

TABLE B.12

APPENDIX C

REFERENCES

1 - Rotz, J., J.E. Edmunds and K. Kaplan - Formation of Debris From Buildings and Their Contents by Blast and Fire Effects of Nuclear Weapons - URS 651-4 Contract No. OCD-PS-64-201 April 1966

2 - Wickham G.E., T.N. Williamson - Operational Planning Debris Removal - Jacobs Associates, TR 110 Contract No.DAHC 20-70-C-0305 - July 1971.

3 - Wickham G.E. - Debris Removal Civil Defense Operations: Volume I - JA TR 101 - Contract No. OCD-DAHC 20-67-C-0136 March 1969